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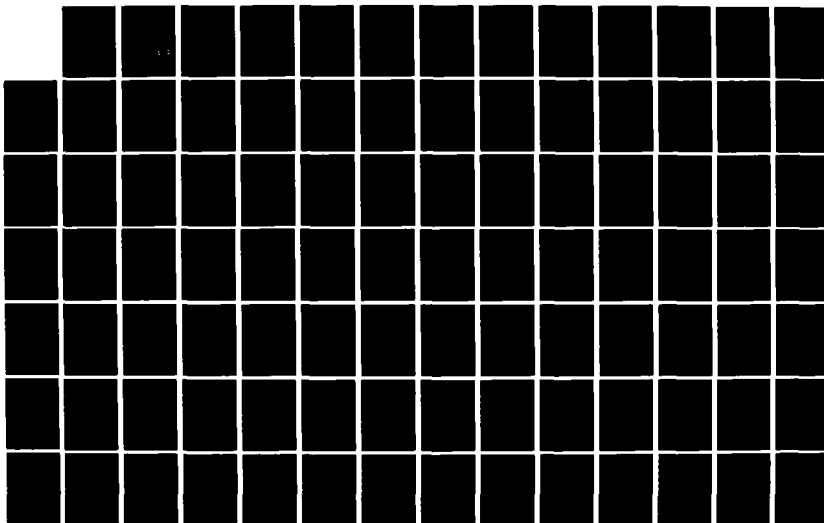
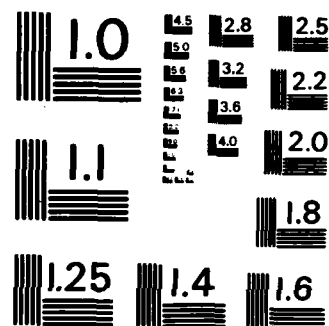ESSEX ORLANDO
TECHNICAL REPORT
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COMPUTER-BASED INSTRUCTION (CBI):
CONSIDERATIONS FOR A USER-ORIENTED
TECHNOLOGY DATA BASE

Norman E. Lane

Grace P. Waldrop

FINAL REPORT

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This report documents 1) an analysis of feasibility and 2) the development of a preliminary structure for a computerized data base on capability and availability of computer-based instruction (CBI) technologies within the Department of Defense (DoD). It concludes that the proposed data base, although logistically complex, can be developed and would be of considerable value in providing ready access to technology information for a variety of DoD users. Rationale for recommendations is based on review and synthesis of the CBI research and development (R&D) literature, structured interviews with a cross-section of potential data base users, and an analysis of existing R&D data bases. This report provides a first step in the data base development process, that of examining the user requirements, issues of importance, and potential development considerations. It also describes the subsequent requirements leading to creation of a user-oriented R&D data base for CBI technology.

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SUMMARY

This report documents 1) an analysis of feasibility and 2) the development of a preliminary structure for a computerized data base on capability and availability of computer-based instruction (CBI) technologies within the Department of Defense (DOD). It concludes that the proposed data base, although logistically complex, can be developed and would be of considerable value in providing ready access to technology information for a variety of DOD users. Rationale for recommendations is based on review and synthesis of the CBI research and development (R&D) literature, structured interviews with a cross-section of potential data base users, and an analysis of existing R&D data bases. This report provides a first step in the data base development process, that of examining the user requirements, issues of importance, and potential development considerations. It also describes the subsequent requirements leading to creation of a user-oriented R&D data base for CBI technology.

Discussions of the problem introduce the concept of a "CBI applications gap" due to rapid but uneven growth of the technology, and a resultant confusion by potential users concerning availability and characteristics of new CBI methods. A brief review of CBI literature is presented, along with indications of general trends in CBI research and development and some assessments of high-payoff directions for the technology. Reviews, trends and assessments are heavily user-oriented, with emphasis on assessing the impact of technology innovation on users and defining user requirements for technology information. Interviews with CBI developers and other members of the user community were conducted. Inputs were solicited on both practicality and value of the proposed data base and on important ongoing technology efforts expected to be complete in the near future. Results of the survey are generally consistent with findings from the literature analysis and support the need for a technology data base.

Characteristics of alternative data bases are presented and related to user requirements. It is concluded that a data base structured along the lines of a "consumers guide" to available technology is of greatest potential value. The process of providing such a data base goes beyond the simple compilation of available technology information. From the analysis, two important issues were identified. The first addresses the need for specific attention to the characteristics and data needs of potential users of both CBI technology and the proposed data base. The second is concerned with the requirement for taxonomically sound classification schema to aid in collection of information for the data base. The schema should describe features of CBI systems in a form that generates data storage and retrieval cues. A "strawman" version of the schema is presented, which categorizes technology information in terms of Functions Performed, System Characteristics, Training Outcomes and Area of Application. The impact of these two issues on the design and functioning of the data base are examined and described.

SECTION I
INTRODUCTION AND BACKGROUND

There is a nearly universal belief that military training needs to be improved. This belief is shared throughout the diversity of the training community, by individuals at every echelon of involvement. The problem has been articulated by instructors, instructional planners, managers, researchers and even trainees. It is recognized by groups who may agree on little else (almost certainly not the solution), but who share a common understanding of the importance of operational readiness and its linkages to the adequacy and effectiveness of training. The demands placed on the training process have increased greatly with the advances in operational equipment sophistication. New weapon systems require operators and maintainers to possess a steadily larger body of technical information and specific technical skills. Providing training for these requirements via traditional instructional methods has become increasingly difficult. Conveying the information and skills required to operate technologically advanced equipment will ultimately require an equivalent sophistication in the technology of training.

Among the training technologies responding to these requirements is the class of instructional development, delivery and management techniques collectively referred to as computer-based instruction (CBI). Although CBI has yet to realize the full measure of contributions expected from the technology for the last two decades (Kearsley, Hunter & Seidel, 1983; Suppes, 1979), it continues to offer a powerful opportunity for improvements in the effectiveness and cost of training. There has been concern, however, that the numbers, complexity and diversity of available CBI methods have become a source of considerable uncertainty in selecting the most appropriate method of CBI technology for a specific

application. This is to a considerable extent attributable to the lack of attention paid by technology developers and documenters to the issue of the intended end-user of a product, the "consumer" of CBI. Although there is considerable discussion of the need to serve the "user," it is not always clear who the intended user is or where he resides in the training process. Users can become involved in the training process during any of several entry points, including preliminary decisions (programming and budgeting), technology development, instructional development, and instructional delivery and revision. Each of these end-users is legitimate and each can require different types of data about the technology, at varying levels of specificity and detail.

Just as a military system designed without a clear picture of the skills and experience expected from the intended operator is likely to exceed the capabilities of available personnel, so an instructional support methodology without a clear definition of the training and background of the "user" may require an extended team of superbeings to realize its full potential. As Montgomery and Judd (1979) pointed out, instructional development with such systems requires "...a versatile professor, an expert in the subject matter, an experienced teacher with sound but innovative ideas about instructional presentation, and a capable programmer" (p. 20), preferably combined into a single individual. Amidst this uncertainty about end-users, the potential value of CBI is reduced by a lack of understandable information on the availability and characteristics of specific CBI technologies and by consequent tendencies toward inappropriate technology use.

Confusion about intended user characteristics has been aggravated by dramatic changes in affordability of small computers. While availability of powerful, inexpensive processing has broadened the user base for CBI, it has at the same time brought about a rapid expansion of languages,

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architectures and authoring approaches which can seriously confuse potential entrants into the user community who lack formal training in these new disciplines.

These "growing pains" and their impact on the growth potential of CBI in military training are discussed in detail by Funaro and Lane (1985). They address the problem of the CBI applications lag in the more general context of introducing technology into systems, and suggest that periods of rapid technology growth are likely to cause a slowdown in applications while users wait for the technology to stabilize. This process is avoidable only by some deliberate intervention to counteract user uncertainty. Among the intervention actions recommended are an explicit focus on the user or "consumer" of CBI in the form of increased availability of technology data and the systematic use of technology demonstrations to reduce user concerns about technical risks. They conclude that:

- Assistance must be provided to the CBI user in matching his particular needs to the available technology (a "consumers guide to CBI").

- To the fullest extent possible, technology should be standardized across the services and common definitions developed.

- Realistic demonstrations of CBI as a viable method of solving practical training problems should be developed and made widely visible throughout the potential user community.

User concerns about the what, where and how of CBI are by no means unfounded. A recent report by Advanced Technology (1985) presents an extensive review of currently available products, sources and methods in CBI and a description of present technology applications. This "overview" of existing technology requires three volumes (over 600 pages) and some 800 references to deal almost exclusively with Air Force requirements and applications. Montemerlo and Tennyson (1976) present over 4000 references prior to 1975 in the general context of instructional systems, of which over 200 deal specifically with CBI. Kearsley

(1983), in his book on CBI method selection, provides 180 references. The review conducted for the present study, to be described later, examined over 1600 citations in various areas of CBI technology. The sheer magnitude of available methods and the massive literature on CBI in its various forms is burdensome to the professional in the area and almost certainly overwhelming and impenetrable to the informed layman.

As Funaro and Lane (1985) point out, a critical factor in overcoming lags in technology applications is specific intervention into the technology introduction and transition process. With respect to CBI in the military environment, there has been for some time an awareness of the need to achieve better use of the capability offered by the technology. Pohlman (1984) and Dallman, et al. (1983) looked at CBI software multi-use potential, support and maintenance from a joint service perspective, and described requirements for a software "clearinghouse" function within the Department of Defense (DOD). The Defense Science Board (DSB) on Training and Training Technology (OUSDR&E, 1983) recommended a series of actions to improve the realization of CBI payoff, including accelerated development of the technology and a focus on technology demonstrations. In 1984, in part as a response to these and numerous other training issues, the Office of the Secretary of Defense established the Defense Training Data and Analysis Center (TDAC) in Orlando.

The TDAC is a DOD-level organization charged with supporting systematic use of training technology within the DOD and with providing to the services data and assistance on evaluation of training effectiveness. Among the much broader functions of the TDAC is the tracking of training technology developments within DOD to determine best use of the technology and to help potential users in sorting out those methods most appropriate to their requirements. Within that broader charter, an early priority has been a focus on CBI technology and specifically on

data base issues associated with dissemination of technical information to users. This report describes one part of a coordinated inhouse/contract series of evaluative surveys and analyses directed toward obtaining, organizing, storing and retrieving the data needed to provide this decision support. In addition to the present document, findings of this effort are presented in Funaro and Lane (1985), Lane (1985) and Waldrop and Lane (1985). While much of the material is reproduced here, these articles provide some additional context and rationale on selected topics. Because of the lack of general availability of the Lane (1985) document, the presentation materials are provided here as Appendix A.

The effort leading to the insights described in this report focused initially on the definition of current and projected work in research and development (R&D) for defense-related CBI. The general approach was a) to provide an abbreviated "snapshot" of present CBI capabilities and methods, b) to examine and describe ongoing R&D in terms of its enhancements of present capabilities, then c) to discuss user issues for an examination of CBI classification schema, and finally d) to project the outcomes of proposed and planned R&D on the availability of new methods in the near future. This capabilities definition is aimed at providing a basic framework for the eventual establishment of a "users" or "consumers" guide to CBI technology in the form of a data storage and retrieval system.

In such a context it is obviously critical to examine in detail the characteristics of potential users of a CBI technology data base and their likely requirements for information. As later discussions will document, the term CBI covers an extraordinarily broad spectrum of terms, categories and classifications, rarely with consensual meaning among authorities and almost never among laymen. Some form of assistance to the diverse user community in accessing CBI information sources is essential, and its absence is steadily

increasing in impact. Zemke (1984) reinforces this pressing need for consumer guidance, suggesting that increased availability of commercially published CBT has changed the task facing the trainer from justifying the use of the medium itself to selecting and exerting quality control over courseware, whether off-the-shelf or custom designed. Funaro and Lane (1985) describe the data base conceptually as a series of "file drawers" into which the user can look to determine approaches that might be appropriate for his or her specific application, combined with a way of determining which file drawer to open and which file to examine first. This guidance should be available for both state-of-the-art, established methods and for those technologies just emerging from R&D.

Providing a "consumer oriented" data base requires careful attention to both what should be in the data base (the contents) and how it should be organized and accessed (the structure). Although the present effort necessarily addresses both issues to some degree, the main focus is on organization, the "how to" of data structures.

In the process of analyzing and synthesizing available information on past and future CBI, several inescapable conclusions emerged. First, there was no consensus (and very little awareness) among system developers and documenters about who the "users" of CBI technology might be. The "intended user" implied by context of system descriptions suggested a range from an unsupported subject matter expert (SME) with a personal computer to an instructional language specialist with a full courseware authoring language and a multi-terminal mainframe system. Second, the data quickly confirmed a suspicion that it was futile to attempt contrasts of past, present and future CBI without some kind of organizing schema for providing descriptions of various CBI system characteristics. Fleishman (1982) and Fleishman and Quaintance (1984) note (in a slightly different context) the importance of taxonomic structures in

identifying and describing the relationships among elements. Miller (1962; 1975) has emphasized the need for a common framework for both performance and training, and has attempted to develop training taxonomies which provide a behaviorally oriented structure. In particular, Fleishman and Quaintance systematically link the general availability of taxonomies and classifications to both the effective use of existing technical information and the informed shaping and guiding of future inquiry. It became clear early in the present effort that some categorization of methods was essential for the process of drawing generalizations about the status and future of CBI alternatives and approaches.

The remainder of this report will provide an overview of CBI technology status, trends and possible directions, and examine ways of organizing and presenting information on that technology. It will address the CBI "user" issue, present information from interviews with technology developers and potential data base users, and it will examine existing technology data bases, generating a "strawman" schema for classifying CBI system characteristics.

SECTION II
SCOPE

Objective

As previously described, the initial objective of the CBI technology analysis and synthesis was to describe current and near future capabilities of CBI in the DOD environment, with projection of the technology over the next decade and identification of the most relevant applications of the CBI technology. During the conduct of the effort, the need for a second and eventually a third objective became clear -- to define as fully as possible the characteristics and data needs of potential users and to develop a preliminary schema for organizing technology data. The resulting schema would provide a departure point for an eventual data base with a computerized search system to obtain up-to-date information about CBI technologies. Data base entries would contain descriptions of CBI system characteristics on a variety of features important to a potential system user or training decision maker.

Framework and Context

Figure 1 illustrates the overall project framework, in the context of data base origin and use. Ideally, each of the boxes in Figure 1 warrants an in-depth analysis to describe the relationship with other aspects of the framework, as well as with aspects not included in the illustration. The authors conducted a problem analysis on the overall system, geared toward answering questions such as:

- What information should be in the data base?
- Where does the information originate?
- How is it best classified?
- Who will use the data base?
- How will users retrieve the data?

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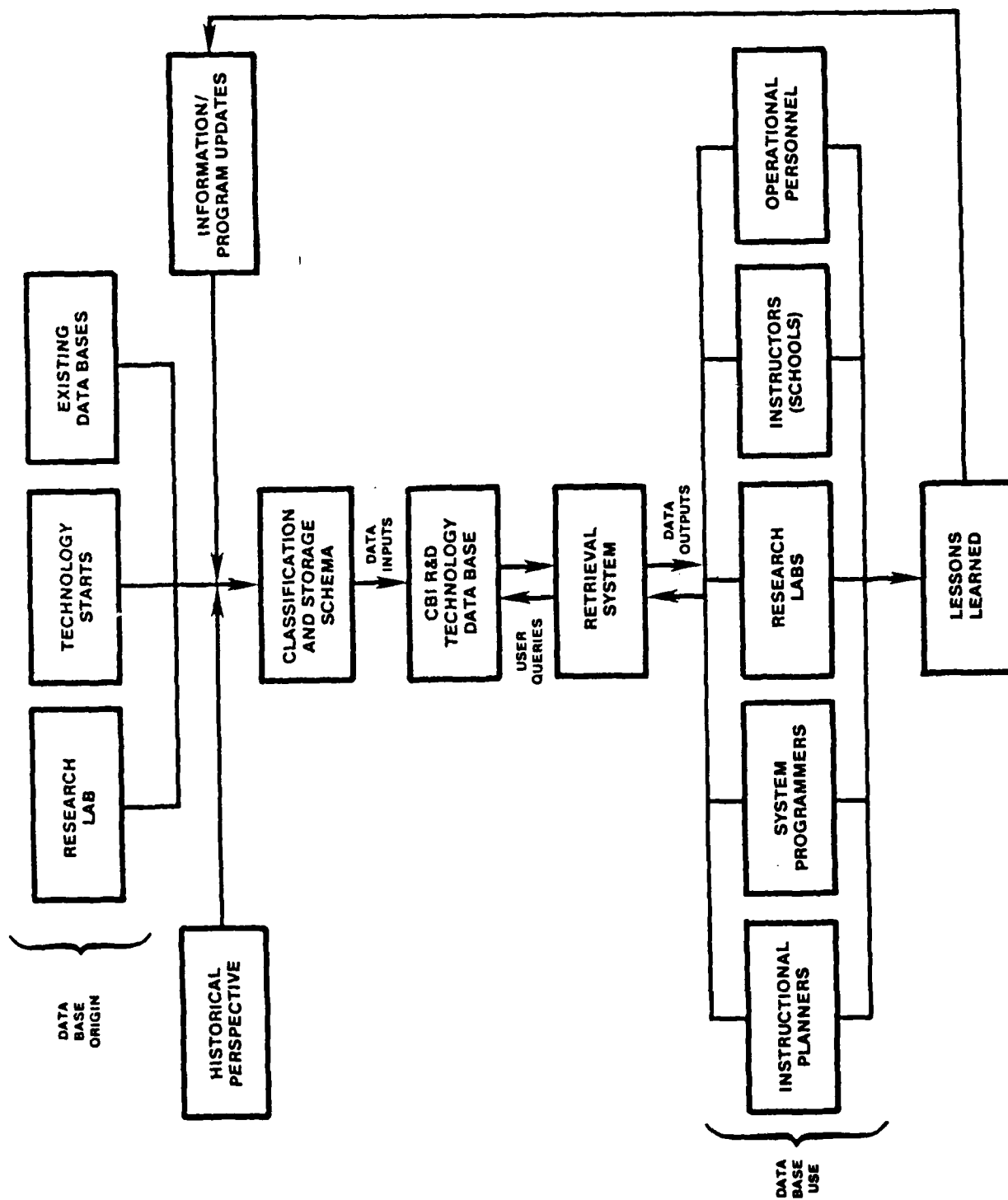
DATA BASE FRAMEWORK
FIGURE 1

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A potential source of confusion in dealing with CBI is the multiplicity of meanings subsumed under the CBI rubric. These definitional issues are the subject of another study by TDAC under its CBI program. For purposes of the present analyses, it was necessary to make a clear distinction between CBI in Applications and computer-supported CBI Development Systems. "Applications" refers to an existing computer-assisted instructional delivery system (CAI) and/or an existing computer-managed instructional (CMI) program. "Development Systems" refers to the multiplicity of computer-supported tools that may be used in the development of an application system. The latter term subsumes such categories as computer-based methods for training cost and resource estimation, courseware authoring, selection of instructional strategies, and similar functions. The technology review and projection described herein dealt primarily with Development System capabilities emerging from ongoing or planned R&D efforts within the DOD, with an additional focus on the preliminary classification schema needed to create a data base and to tie current developments to future requirements.

A further delimiter was necessary to establish boundaries for CBI which were in line with conventional uses of the terminology. Strictly considered, CBI ranges from simple applications such as computer presentation of textual information to large-scale full system simulations (such as aircraft simulators with visual/motion capability). (See Peters (1982) and Micheli, Morris & Swope (1980) for illustration of the diversity of the CBI terminology umbrella). To allow reasonable boundaries for the effort, such categories as text automation, full mission simulators and embedded training hardware (but not necessarily software) were excluded from consideration. Otherwise, the working definition covered all DOD-related R&D work intended to extend the state-of-the-art in instructional development, delivery and management through the

use of computer support for some aspect of the instructional process. Personnel involved in other TDAC projects are reviewing commercially available CBI and developing detailed CBI definitions and terminology.

Existing Data Base Utilization

One of the TDAC functions is to integrate and augment existing operational data bases to focus on analyses of longitudinal and historical training data. Existing sources of data have been designed for a variety of other purposes and are not always fully compatible. The authors made no attempt to gather the data necessary for creation of an R&D data base. With the understanding that existing data bases will eventually provide a departure point for needed inputs, this project defined potential users and sampled current R&D programs, in an effort to recommend a classification schema for the data base, prior to extensive collation of existing data. The authors examined one particular type of information (CBI R&D within DOD) from the user's perspective toward the most efficient method of classification. While an extensive review and analysis of existing information systems would be a considerable effort, the authors did attempt a cursory look at CBI R&D data bases; who uses them, how and why they use them, and the pros and cons associated with that use.

SECTION III
METHOD AND APPROACH

Initial Technical Review

The project required several different but related efforts, the analysis of CBI R&D toward a user-oriented data base being the overall goal. Early in the project, a technical review paper (Funaro & Lane, 1985) provided a conceptual analysis of the CBI applications gap as a problem in "acceptance of innovation", and identified several specific actions required to encourage application of the technology. The article laid the theoretical basis for the concept of the CBI data base as a "consumers guide" and for the role of user support systems and organizations.

Literature Review

An extensive literature search was used to acquire initial information for scoping the analysis and establishing the preliminary structure of the classification schema. A bibliographic search by the Defense Technical Information Center (DTIC) identified about 1300 defense-related articles in the CBI/CAI/CMI topical areas since 1975. A search of Work Unit Summaries (DD 1498) for a similar period was used to augment the authors' own knowledge of R&D activities within DOD and to ensure that work completed over the last decade was not overlooked. Journals and other reference sources yielded in excess of 300 additional citations. From these initial abstracts, about 350 articles were considered which dealt primarily with the technology of CBI (vs. applications), including a number of citations available from secondary sources in prior reviews. Approximately 150 articles were reviewed in depth; of these, only about half were directly and uniquely germane to purposes of this analysis. The final reference list

of 90+ citations from the R&D literature is contained in Section
IX: References.

Interviews and Survey

The initial literature review was supplemented by
cross-checks with government project personnel working on
related efforts and other specialists within the authors'
organization, and by informal discussions with active CBI
research personnel in a variety of settings, such as conferences
and professional association meetings. These efforts were
directed at sketching out the preliminary technology
classification schema to be used in further data collection.
Formal "interviews" were conducted with investigators from the
major DOD R&D agencies with active interests and knowledge in
CBI technology development and with a selected cross section of
possible users of the CBI data base to expand and revise the
strawman schema (see Table 1). Interviews served to obtain the
broadest possible representation of user concerns in the schema.

Interviews were structured so that each resulted in a
similar type of information and level of specificity, while at
the same time allowing for flexibility in the discussion.
Appendix B contains the interviewer's outlined survey guide,
used to structure the interview so that a certain set of
specific topics was addressed at a minimum, with no constraints
on any other aspects of discussion. The structure consisted of
first establishing the type of potential user being interviewed,
e.g., a planner, researcher, instructor, etc., followed by
discussion of critical aspects of the data base structure, e.g.,
retrieval systems, updating methods, content, etc. The CBI
researchers were queried not only on their current and probable
future use of data bases, but also on their current technology
research programs. Users were sampled in both the instructional
development field and in the delivery of operational training.
The fleet community was included to discover what, if any, use
they might have for a CBI R&D data base, since they are the

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TABLE 1
PARTICIPANTS IN THE SURVEY

NAME	AFFILIATION
James M. Bolwerk	Commander, Naval Air Force Pacific Fleet NAS North Island, CA
Carl R. Driskell	Army Program Manager for Training Devices (PMTRADE) Orlando, FL
Dr. Sharron P. Gott	Air Force Human Resources Laboratory, Brooks AFB, TX
John Hayes	Army Research Institute Alexandria, VA
Dr. Robin Keesee	Army Research Institute Alexandria, VA
Allen Marshall	Air Force Human Resources Laboratory, Lowry AFB, CO
Dr. Frank W. Schufletowski	Air Force Air Training Command Randolph AFB, TX
Dr. Zita Simutis	Army Research Institute Alexandria, VA
Dr. Robert Wisher	Army Research Institute Alexandria, VA
Dr. Wallace Wulfeck	Navy Personnel Research and Development Center, San Diego, CA

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ultimate recipients of the success or failure of the training program. These interviews provided information on both the needs of the data base user and the information which would eventually go into the data base.

Data Bases

Existing CBI data bases provided information on what is currently available and how useful this available information is to the community. The authors made no attempt to critique the existing data bases, but rather examined them from the perspective of their applicability to CBI technology R&D. The information stored in these data bases could eventually serve as a part of the inputs to the newly classified CBI R&D data base. Important to this process was how the data were stored, updated and retrieved, and the content of the individual files. The field interviews yielded information from users on how often they use the features available in current data bases, the aspects considered beneficial and those not used.

SECTION IV
CBI REVIEW

Perspective on the Review

Since long before its emergence from programmed instruction, CBI and its subcomponents have generated an extensive literature. We noted earlier the magnitude and diversity of CBI-related studies, subsuming as they do progressively more significant portions of the literature in education and instructional technology, instructional psychology, cognitive psychology, training, computer hardware and languages, simulation and gaming, artificial intelligence and expert systems. There are available many excellent histories, reviews, evaluative summaries and technical forecasts. These are both general in nature and specially focused, covering CBI theory, methods and techniques, guidance for use and effectiveness in a variety of instructional contexts. A sampling (with some comments on context) is given in Table 2.

It is not the intent of this section to provide still another review or to recapitulate the findings and recommendations of previous ones. As is apparent from earlier sections, our concern is with "users." More specifically, emphasis is on what the diversity of user requirements (for technology and/or information) may mean for a CBI data base or guidance system. We will thus focus predominantly on literature which deals with the likely impact of CBI technology on users with specific selected functions in the instructional decision making, development, delivery and management process.

Effectiveness of the Technology

The value of CAI and CMI in improving or maintaining training effectiveness with reduced training time is well documented. In the CAI domain, Orlansky and String (1979) and Orlansky, String and Chatelier (1982) describe a review of 48

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TABLE 2
CBI REVIEWS

REFERENCE	CONTEXT
Ace, Sendefer and Sciutti (1983)	Computer-assisted ISD techniques
Advanced Technology (1985)	A compendium of CBI current CBI techniques, methods and products
Back and McCombs (1984)	Literature on implementing self-paced and individualized instruction, predominately CAI
Berkowitz and O'Neil (1979)	Bibliography of ISD including CBI
Branson (1984)	Business and industrial applications
Chambers and Sprecher (1980)	Emphasis on hardware/software issues
Dean (1977)	Benefits and risks of CBI
Fletcher (1975a)	State-of-the-art survey and critical issues
Fullan and Pomfert (1977)	Curriculum and instructional context
Gerlach (1984)	Instructional trends with some reservations about CBI research
Hickey (1975)	Survey of research in CAI
Kearsley, Hillelsohn and Seidel (1981)	Business and industrial training
Kearsley, Hunter and Seidel (1983)	Evaluative survey of 20 years of CBI research

TABLE 2 (con't)
CBI REVIEWS

REFERENCES	CONTEXT
Kearsley and Seidel (1985)	Automation of training and training development
Kemner-Richardson, Lamos and West (1984)	Resource guide for instructional decision makers
Kulik, Kulik and Cohen (1980)	Effectiveness in college applications
Micheli, Morris and Swope (1980)	Technology forecast for '80s and '90s
Montemerlo and Tennyson (1976)	Bibliography and review of ISD
Meierhenry (1984)	Educational methods context
O'Neil (1981)	Collection of summaries of CBI status
Stephens (1979)	Analysis of factors in successful CBI applications
Suppes (1979)	Review of key technical areas with forecasts
Wexley (1984)	CBI in context of training

applications in military settings. The typical application achieved an effectiveness equal or slightly superior to conventional instruction with a time savings of about 30 percent. These findings were in general confirmed by Babbitt, Pieper, Semple and Swanson (1985), who performed a similar comparison for studies from 1977-1984. While CBT continued to show a superiority over conventional instruction, differences were not as large as those in earlier studies summarized by Orlansky and String (1979).

Kulik, Kulik and Cohen (1980) performed a meta-analysis of 59 studies from the college instruction domain. Their findings closely parallel those of Orlansky and String. CBI increased student achievement by about 0.25 standard deviations, while reducing the time required for instruction by 36 percent. Kulik, Kulik and Bangert-Drowns (1984) repeated the analysis for elementary school applications, reporting an achievement increase of 0.48 standard deviations.

Sprecher and Chambers (1980), in another review, suggest a reduction in mean time from CAI of 50 to 67 percent, somewhat larger than that of Orlansky and String, but from studies covering a broader domain. Montague, Wulfeck and Ellis (1983), in a carefully planned CAI experiment, found a decrease in training time similar to that indicated by Orlansky and String (about 27 percent), but also reinforced the concerns of Orlansky and String that the cost savings from CBI associated with reduced time have not yet been realized because of lockstep training schedules.

In general, where appropriately used, CAI can clearly both save time to train and increase typical levels of achievement. As with most such generalizations, this is not universally true. CAI can have little or no impact (the effect sizes reported are not large), or even negative effect (see Gerlach, 1984). Kearsley (1983), Stephens (1979) and Zemke (1984) provide excellent summaries of conditions under which CAI

applications are most beneficial. In assessing the overall instructional value of CAI, it should also be considered that creative application of CAI technology (particularly intelligent CAI) can provide training for which other methods are inadequate, too risky or too costly.

CMI systems in various forms have been in place in military settings for almost 15 years (Berkowitz, O'Neil & Wagner, 1980; Swope, Corey, Evans & Morris, 1982), and their strengths and weaknesses are well established. The literature on CMI is generally supportive of its effectiveness. Dollard, Dixon and McCann (1980) describe a shipboard system for management of damage control training. They found increases in student thruput, higher achievement, and reduction in administrative requirements, as well as positive attitudes from instructors. Swope et al. (1982) report an effective management of student flow in the Navy's Memphis CMI system and a general satisfaction with system performance (see also Van Matre, 1980; Federico, 1984). Johnson, Graham & Carson (1982) found individualized CMI courses to be superior to conventional instruction for relatively complex maintenance tasks, with no difference in later job performance.

Despite these and other indicants, broad statements about CMI effectiveness require qualification in the relationship of CMI to the pacing of instructional sequences. It is likely that the positive effects of CAI result from its ability to effectively individualize instruction. CMI, on the other hand, can act either to enhance individualization or to suppress it, depending on its design and its implementation. Micheli and Ford (1983) suggest that a lack of understanding of CMI by some training managers results in a failure to capitalize on the benefits of individualized instruction. Most studies find distinct interactions between methods of pacing instruction and student ability. Baldwin, Cliborn and Foskett (1976), Federico (1984), Hall and Freda (1982), and Taylor, Montague and Hauke (1970) report superior achievement from high ability students

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under self-paced instruction, but not under group-paced conditions. There are strong indications that CMI systems, to be consistently effective, must accommodate individual differences in ability and rate of learning.

Even with the positive track record of CAI and CMI, there is still uncertainty about the extent to which success of the technologies is due to the computer media in itself. Kearsley and Seidel (1983) indicate that most of the potential benefits of CBI are not inherent in the computer; they come about because of careful instruction and good instructors. Clark (1983), in a meta-analysis of media effects, concludes that there is no competent evidence that media are a causal factor in learning and that effectiveness is due to other aspects of the instructional situation. This conclusion is strongly reinforced by Gerlach (1984), who suggests that the benefits of CBI may be due solely to systematic development of materials. Meierhenry (1984) also points out that media are no more than instructional delivery mechanisms, and do not promote learning other than as agents of good instructional materials. Branson (1984) contends that effectiveness of instruction is more influenced by effectiveness of management than by delivery media or materials, and Evans and Braby (1983), in a departure from most analyses of individualized instruction, conclude that course effectiveness is predominantly due to sound instructional practices, rather than to delivery method or to method of pacing.

Evolution and Revolution in CBI

What is now known as CBI, in particular the CAI components, evolved rather gradually over several decades from programmed instruction and teaching machines into a reasonably well-defined technology alternative to conventional education and training methods. So long as implementation was constrained to mainframe and minicomputers, progression of capabilities followed this evolutionary course of steady

refinement and improvement. As with most other technical areas, however, the power and affordability advantages of microcomputers brought about an "overnight" shift in what was possible with CAI and CMI. In particular, the marriage of CAI and microcomputers was an unusually fruitful union, enabling training approaches impractical under other approaches. These new capabilities materially steepened the growth curve of CBI technology, bringing about the oft-noted "revolution" in CBI. Funaro and Lane (1985) suggest that such revolutionary changes in capability tend to confuse the potential consumer of new technology, with a resultant tendency for the new entrant to stay out of the marketplace (for videocassette recorders, home computers, or CBI) until the technology growth curve appears to have levelled off.

The CBI revolution has brought about two major complications for the DOD user community. The greater affordability of CBI has enabled and encouraged a wider range of users to become involved in the selection, designing and using of CBI. At the same time, the difficulty of choosing between increasingly larger numbers of complex alternative approaches requires progressively higher levels of expertise in the technology. The need of more users for "data" about CBI system characteristics thus coincides with a mushrooming of the amount and complexity of those data. This impact is pervasive throughout the instructional delivery system. It affects the decision maker, the instructional planner, the instructional designer, the instructor and the student -- individuals with diverse backgrounds in CBI familiarity and dramatic differences in criteria for what they expect from an instructional system.

A User-Oriented Review

In the remainder of this section we address concerns about users from the standpoint of the literature, what is known about users in their interactions with instructional development and delivery systems. Section VI provides

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perspective on these concerns from a cross-section of the users themselves, and Section VII brings together both kinds of information in the context of CBI data base design.

Implementation of CBI technology at various training levels must take into account the sophistication of users and their willingness and ability to accept and support advanced technology applications. It is thus important to understand the range of user types and their different needs, interests and interaction with the CBI system. As Kearsley (1983) indicates, "...of all the factors that affect the success of CBT projects, user involvement is probably the most important" (p. 134). Montague, Wulfeck and Ellis (1983) convincingly emphasize the importance of user organizational support and user participation in successful implementation of CBI. Draxl and Aggen (1981), in examining a large number of CBI installations, suggest that the only common element in those that were successful was the presence of one or more key individuals committed to the success of the effort. Research described by Fullan and Pomfert (1977) shows the criticality of implementation support above the instructional delivery level and of a willingness to "compensate" for introduction of new approaches by changes elsewhere in the system. Processes of soliciting user inputs and ultimately providing CBI users with up-to-date information are crucial aspects of achieving user acceptance and support and are thus critical to a successful CBI implementation.

Discussions in Section VII identify some eleven different classes of CBI "users." Each of these user groups has unique technology data base requirements and each is differentially impacted by technology change. Serving user requirements for CBI information thus involves the consideration of many distinct descriptors of system characteristics. These include (but are not limited to) such factors as the following (adapted from Funaro & Lane, 1985):

* Transportability (compatibility of language, hardware, dependence, special system features, or communication protocols),

* Scope of Coverage (full system including instructional development, delivery and student management versus selected coverage),

* Characteristics of Student Tracking, Reporting and Feedback Systems (for CMI),

* Background/Characteristics of Intended User (SME, training manager, analyst; knowledge expected, special training required),

* Degree of System Tailoring and Maintenance Required (off-the-shelf generic versus investment required for customizing applications),

* Presence/Absence/Characteristics of Authoring Language and/or Authoring System (extent of support and complexity of use),

* Nature and Completeness of User Documentation,

* Cost Involved and Dependability of Cost Estimation,

* Hardware and Physical Interface Requirements,

* Embedding of Educational Principles (Is theory of instruction provided by system or by user),

* Personnel Requirements for System Operation (operations, update, maintenance, etc.), and

* Availability to the Government (Proprietary versus Public Domain).

This partial list of system descriptors suggests the comprehensiveness of materials with which potential users must deal. Discussions which follow focus on the functions of individual users within the military training process, and describe some considerations from the literature about data requirements which bear on effective performance of their functions.

Instructors. Much of the early implementation of CBI proceeded without any concern for the impact of the methods on the instructor. It was felt that effects could only be positive -- reduced workload, less administrative responsibility, more

time to spend with students, and so forth. There was thus some considerable surprise (and probably some hurt feelings) when the reception by instructors of this potential boon was not only frequently unfavorable, but sometimes hostile (Fullan and Pomfert, 1977; Kearsley, 1983). Sherron (1976), in a survey of hundreds of instructors and managers in military CBI environments, found their attitudes to be highly critical of those CBI implementations which failed to consider impact at the delivery level, particularly those which increased their adminstrative burden and reduced their contact time with students. Sherron's data suggests not so much an overt hostility to the introduction of CBI and similar innovations, but rather a strong skepticism as to the chances of their working-level realities being considered in design and implementation of future "advanced" training systems.

The literature is conclusive that instructor acceptance is virtually mandatory for successful implementation of any training system, regardless of the form of instructional delivery. It is equally clear that acceptance goes beyond a merely passive reaction; instructors should participate in the development of the instruction and, more importantly, should understand the nature of any new technologies and how these relate to their carrying out of instruction. Evans and Braby (1983) describe the inability or unwillingness of working level instructors to deal with subtle distinctions between delivery technologies, lumping together (and frequently ignoring) techniques whose differences are clear to specialists in education and training disciplines. To most instructors, programmed texts, self-paced CBI, and learning centers are all the same and all equivalent to "new" technology. To the extent that one approach is perceived as unsatisfactory, the "blame" is borne by instructional innovation in general. Back and McCombs (1984) make a similar point, suggesting that the sometimes negative reception of self-paced instruction is largely due to poorly implemented CBI, with or without self-pacing. Thus, for the potential of innovation to be realized, instructor issues

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should extend beyond the well-known requirement for instructor involvement in the development process. They encompass a specific attention to the information needs of instructors as a crucial factor in acceptance. As previously noted, these needs will differ slightly from those of individuals elsewhere in the delivery process and will likely involve information on why a certain delivery approach is used and how to employ it effectively.

To a significant extent, the use of CAI and CMI has changed the role of the instructor, and not always consistently. Changes have been in some cases negative; Sherron's (1976) instructors report loss of student contact time due to administrative responsibilities. There are directly opposing findings; in the study reported by Dollard, Dixon and McCann (1980), the introduction of CMI decreased administrative burden and increased opportunity for student contact. The long-term trends appear to support the latter outcome (Kearsley, Hunter & Seidel, 1983). McCombs and Dobrovolny (1980; 1983), in a thorough analysis of instructor functions under conventional and computer-based systems, describe some gradual but relatively permanent shifts in instructor roles. They show that, under well-designed CBI, instructors move toward tutor, counselor and advisor functions, and away from planner, monitor and diagnostician responsibilities, with these latter functions more commonly performed by the computer. From Sherron's findings (1976), and those of other research, by far the majority of instructors believe the counselor/tutor role to be of overriding importance. Back and McCombs (1984) indicate that one of the crucial factors in successful CBI implementation is a well-defined instructor role (understood by the instructor), and suggest that criticisms of individualized instruction are due directly to feelings of loss of control experienced by instructors in a poorly-designed CBI environment. In this context, the shifts identified by McCombs and Dobrovolny (1980; 1983) are clearly in the right directions and should increase positive perceptions of the methodology by instructors. Other

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factors may also be important for acceptance. Francis, Welling and Levy (1983) found that instructors' acceptance and appreciation of simulation CAI were directly related to the existence of alternatives. Where actual equipment was limited, satisfaction was high; where it was plentiful, training on simulated equipment was somewhat less attractive.

Providing instructors with information about the training system can enhance both acceptance and effectiveness. McCombs and Dobrovolny (1983) show that, through training and orientation, instructors are more likely to understand and thus to accept and to make effective use of computer-supported training systems. This understanding of the system is in addition to passive acceptance, and appears to be an important factor in achieving an integration of computer courseware and CMI into the overall instructional pattern. Anderson (1980) factor analyzed courseware ratings. One of the five major axes of courseware desirability was ease of integration, the extent to which training materials could be utilized without disrupting instructional flow. Shavelson and Winkler (1982) conclude that the best use of CBI is in an integrated mode with existing instruction in an established instructional setting, and suggest that the technology may not be cost effective when used in other ways. In their view, instructors perform so many functions, and are so central to both the management and delivery of instruction, that "replacing" instructor functions by computer would be prohibitively expensive and can be rejected on those grounds alone, regardess of possible effectiveness issues.

In sum, instructors need information which helps them understand new training materials and use them as intended in an environment of heavy interaction with the student. Without such infcrmation, acceptance is likely to lag and full effectiveness will not be realized.

Designers and Authors of Instruction. Of all the potential classes of CBI users, there is the greatest lack of consensus

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about the characteristics of those who structure and author courseware and course management systems. For no other participant in the development and delivery process are the technology developer's perceptions about user knowledge, background and organizational location so diverse. There is still implicit in most methods for development of CBI (particularly CAI) an assumption that people who know the subject matter (SMEs), interacting with a computer through some software-managed dialogue, will somehow produce acceptable course materials. This assumption is in essence an embedded belief (or hope) that : SME + AUTHORING LANGUAGE = EFFECTIVE INSTRUCTION. While this is likely true is some cases, it is incorrect more often than not, and the training and experience required of designers and authors has become a subject of considerable concern in the literature.

We have discussed previously the conviction of many authorities that CBI works primarily because of the systematic attention to instructional material it brings to the development process, and the extent to which quality materials can override method of delivery (Clark, 1983; Evans & Braby, 1983). Media selection approaches were employed effectively prior to routine use of CBI (Braby, Henry, Morris & Swope, 1975; Spangenberg, Riback & Moon, 1973) and the Systems Approach to Training (SAT) dates back to the 1960's (Montemerlo & Tennyson, 1976). Given such findings, it is not surprising that the need for CBI has been questioned (Gerlach, 1984), raising the query as to whether any other similarly systematic approach might not work as well. In that context, the quality control of materials is paramount, and some standardization of approach, if not of language, is important. Kemner-Richardson, Lamos and West (1984), in their CAI Decision Handbook, identify four general classes of CBI development "teams" as currently applied. These are (somewhat paraphrased):

A. The Inspired Programmer-Author -- The "team" consists of an SME who learns the languages.

B. The Traditional Development Team -- An instructional designer, an SME, a programmer, and graphics and editing personnel as required.

C. The Computer-Supported Development Team -- Instructional designer and SME guided by an authoring system.

D. The Computer-Guided Author -- An SME guided by an intelligent or "expert system" for complete instructional design.

A similar distinction is made by Bunderson (1978), who characterizes author-supporting mechanisms (models, languages, systems) as "Artistic," "Empirical," and "Analytic," according to the extent to which theory and prescriptive guidance are embedded in the mechanism and the degree to which the user provides or is provided with the structure.

The above articles, along with Montgomery and Judd (1979), suggest a trend away from the cross-training of a single individual in all the requisite skills, and toward the current "traditional" team, composed of a number of individuals who collectively provide the experience and training required for effective production. Such a team, made up of an SME, an instructional development specialist, and, depending on the application, a programmer, would eventually evolve into a smaller team, similar to type C or D above. Team composition, and ultimately, whether or not the team approach is required, will depend heavily on the progress of developments in authoring languages and authoring systems. These serve to translate subject matter knowledge and training objectives into courseware by "mediating" between the developer and the desired instructional system (Schwartz, 1983).

Authoring languages have existed in one form or another almost since the beginning of CBI, and have evolved steadily along with other aspects of the technology. Authoring costs represent the largest component of CBI costs (outstripping

hardware for most applications) (Kearsley, 1982), and are at the same time the most variable (Zemke, 1984). Several excellent reviews of current authoring languages are available. Advanced Technology (1985) presents a compendium of languages with references and commercial sources. Locatis and Carr (1985) list more than 60 available authoring languages. Kears. (1983) provides some criteria for selection of a language for specific applications. Bunderson (1978) and Zinn and Bork (1978) discuss some theoretical issues in language development and present some of the special concerns of language use in the military training environment. Reigeluth (1979) gives a summary of the TICCIT system and illustrative applications. Himwich (1977) presents a comparison of PLATO and TICCIT applied to the same training problem; he notes that while the languages have different strengths and weaknesses and are likely to be differentially effective for varying applications, in no case did the courseware authors take full advantage of the special features in either approach.

The Himwich (1977) study illustrates a key problem in the use of authoring languages; without appropriate training or experience on the part of the developer, even the most primitive of languages may offer capabilities that exceed the developer's skill. As Bunderson (1978) points out, military systems are particularly vulnerable to this "production learning curve". He cites four major reasons for this vulnerability:

- Turnover in military author or SME populations,
- Lack of formal author training,
- Lack of author control over content, and
- Precedence of production concerns over innovation.

A particularly costly result of the factors identified by Bunderson is the tendency by developers, in the absence of guidance or formal computer support, to produce computer presentations of already existing course materials, the so-called "text automation". (We might consider this the

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"Uninspired Programmer-Author".) As Montague and Wulfeck (1984) (along with many others) point out, "...as long as instruction is text-based and teaching is to the same specifications, little or no difference is found" (between computer and texts). A key aspect of overcoming text automation approaches is the availability and use of underlying systems. Authoring systems extend the capability of authoring languages by providing structure and guidance in how to use the language for instructional purposes. They may contain user training modules, embedded "expert systems" representations of how instruction should be organized and sequenced, special "formats" for instruction presentation, and other features which lead the author through the development process on the basis of instructional objectives combined with some embedded theory of instruction (see Bunderson, 1978; Kearsley, 1984; Merrill & Wood, 1984).

Until very recently, use of authoring languages required access to a mainframe or minicomputer. Most of the major languages are now available in microcomputer format with little loss of power (see lists in Advanced Technology (1985), Vol. II, Appendix F). The more complex and sophisticated authoring systems are likely to follow the same development path. Contrasting current capabilities with those of the middle 1970's (Berkowitz & O'Neil, 1979), suggests real progress over that period. Berkowitz and O'Neil described the authoring aids available for each phase of the ISD model, indicating the lack of computer assistance for many key aspects of the ISD process. Although by no means all of the identified deficiencies have been resolved, significant movement has occurred toward resolution of most, and it is probable that continued increases in microcomputer power will expand these trends. Widespread availability of such capabilities will likely change the nature of the courseware author's functions; as with most such automation, the average quality level of materials produced will increase, but the innovation and imagination exercised by the occasional "artist" will be suppressed. Although Avner, Smith

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and Tenczar (1984) report increased productivity and improved quality as a result of authoring system use, tradeoffs among cost, productivity, and quality factors are likely to be unclear for some time to come.

We noted earlier the effects of microcomputers in expanding the user base for CBI. From our examination of user issues, we believe that the potential community of training developers is materially broader than has been previously suspected. Johnson (1983) treats the problems encountered by training officers in detached operations. Developers at the level cited by Johnson are typically "disenfranchised" by the increasing complexity of authoring aids. He shows that CBI can be used effectively by individuals in a shipboard environment without formal training in either training or computers, if information is provided on how to use the technology and if authoring capabilities appropriate to simpler applications are made available.

Decision Makers, Planners and Managers of Instruction. Individuals charged with a) determining the feasibility and affordability of alternative delivery systems, b) selecting the form and sequencing of instruction within that system, and c) tracking both progress of students and the effectiveness of instruction, need information of a different type and at a different level than those in the two preceding groups. Planning and management of training requires an overall perspective on technical and theoretical issues combined with the realities of quality control, attainment of training objectives, and student thruput (see Seidel & Wagner, 1981). Ineffective management of potentially effective instruction can negate much of the advantage gained by careful instructional development; as Branson (1984) suggests, "Instructional technology products don't achieve results. Only managers achieve results."

Only limited attention has been given in the research literature to problems of managers and planners. The CAI

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Decision Handbook of Kemner-Richardson, et al. (1984), is aimed directly at instructional managers. It provides a well-balanced combination of information on technology characteristics, effectiveness and cost. Portions of Kearsley's guide to CBT selection and implementation (1983) deal with information summaries relevant to the instructional manager role, in particular the sections on instructional effectiveness. He provides guidance on the need to rearrange conventional training schedules for greater flexibility under CBI which is particularly critical for successful CBI management. Kearsley (1982) provides similar data and guidance on costs of CBI. Both Kearsley books, in particular the 1983 guidance on selection and implementation of CBI, are directly applicable to concerns of the government or industrial decision maker.

There are striking consistencies in the literature with respect to information potentially useful to decision makers and planners. Stephens (1979) collected from the literature 113 descriptions of factors leading to successful or unsuccessful CBI implementation. He found that all of these descriptions could be grouped under three broad categories:

- <u>Effectiveness</u> -- Does the system do what it is supposed to do? Does it meet objectives?

- <u>Efficiency</u> -- Does it do what it does well? Does it require a resource expenditure appropriate to its effectiveness?

- <u>Practicality</u> -- Can it work under the unique constraints of the organizational situation? Is it appropriate for implementation under the conditions prevailing in the intended environment?

Answers to these three broad classes of questions would clearly be of greater value for decisions <u>prior</u> to selection of a given system than for a post-mortem evaluation. For decision making needs, information bearing on these major issues should be readily available for each system alternative in a form that allows ready comparison among the characteristics and the applications histories of possible choices.

These questions can obviously be expanded almost infinitely to progressively finer levels of detail without losing their generality. The system descriptors presented earlier in this section (Funaro & Lane, 1985) can be seen as special cases of the three classes. Factors on which data must be provided to a decision maker -- technical risk, schedule risk, training time, resource requirements, cost and accuracy of cost estimation -- have their eventual impact through one or more of the classes.

Students. While the trainee is unlikely to be a "user" of the CBI data base, he (or she) is, along with the instructor, hardware, software and courseware, a critical component of the delivery system. As such, outcomes of student interactions with other components of the system are likely to be an important part of the data base. He/she can also be a "designer" of training, since self-paced training allows the student to determine a significant part of the training paradigm. Further, trainees are the recipient of the training system, affected by the quality of materials and by good or poor implementation. Poor CBI can significantly reduce instructor contact. The "acculturization" of recruits in military behavior or protocol, traditionally provided by in-depth interaction with the instructor "role model," is frequently seen as inadequate by the operating units. The perceived culprit is the instructional technology itself, not its implementation, and there is continued risk of discarding both "baby" and "bathwater". Readily accessible data about the possible effects of new technologies on the student and the instructional situation may be required to avoid such reactions.

As authoring capabilities and resulting courseware become more sophisticated, there are long term tendencies to accommodate to more than one instructional pattern within a training course. Understanding how students learn, and isolating variations in the rates and patterns of that learning,

has become a major focus for instructional technology. This upsurge toward "cognitive psychology" has been so dramatic that Gagne and Dick (1983) and Resnick (1981) suggest that the behavioral research aspects of instructional technology have now become a subset of the cognitive psychology domain. There has been for some time an awareness that intelligent CAI would require the ability to model a student's learning, to predict the events and time course of training (see Fletcher, 1975b; Sleeman & Brown, 1982; Suppes, 1979). Student models are required to evaluate alternative training approaches prior to selecting a training configuration (Bunderson, 1978), and for refinements in individualizing instruction (Hall & Freda, 1982). Accurate models are dependent on quantitative representation of student learning. Such models both require data and provide it; properly constituted, they can take unsynthesized information from basic research and translate it into statements of potential system effectiveness directly usable by training decision makers and planners.

As with instructors, the attitude of students toward CBI and their acceptance of the technology is well understood as an important implementation factor (Back & McCombs, 1984; Stephens, 1979). Exactly how students feel about CBI is not so clear. Orlansky and String (1979) found students generally positive to CAI. Knerr and Nawrocki (1978), reviewing the literature on student attitudes, report a lack of any pattern or consistency across studies. It is likely that students' reactions are situation specific, dependent on both the characteristics of the delivery system, the instructor's attitude, and the instructor's use or lack of use of the system.

Trends in the Technology.

Predicting the future course of any technology area is fraught with risks. As Suppes (1979) points out, one is likely to be wrong both on what will happen and when it will happen,

and the process of putting such forecasts into print is often a forerunner of later embarassment. Nonetheless, over the course of inspecting over 1500 CBI-related items, some impressions of direction for the technology will of necessity emerge. These impressions are subjective assessments and integrations, in general not attributable to any single article or item of literature, and based primarily on perceived shifts in the subject matter being pursued by workers in the CBI R&D field over a decade or more of time. We will qualify our discussions by insisting that they be considered as trends, tendencies for the technology to gravitate in certain general directions, without any great confidence in the time course in which these movements are likely to occur.

Despite more than 25 years of history, CBI technology is still a young and immature field. As previous sections note, much has been written about the future of the technology and its potential for changing the nature of instruction. That far too little of this potential has been realized may be due not so much to the inability of the technology to deliver what has been "promised" as to the time frames in which the contributions were to take place.

At various times, CBI has been presented as being cheaper, faster, more powerful than other educational alternatives. Much of this has turned out not to be completely true - yet. But it likely will be, eventually. A significant part of what has been been expected has already arrived. Technology capabilities exist far beyond those presently utilized. In achieving utilization, however, it is important that the capability and affordability of technology should progress together. Throughout much of the history of CBI, hardware, software, instructional theory and cost have been chronically out of phase. Each of these parts of the CBI package has its own relatively independent set of drivers and tends to move at its own pace. It is thus not the inability of CBI to provide what users want, but the difficulty encountered in getting the

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technology act together. As a result of hardware developments, computational power is available for great accomplishments at acceptable hardware costs; the affordability of courseware authoring and the sophistication of instructional theory have not, however, progressed rapidly enough to match the computational capability and thus serve as constraints on overall applicability of the technology. These components will in future realign themselves; in the interim, evaluations of CBI technology potential should consider the developmental phasing problem in assessing the probable worth of CBI.

Previous forecasts of directions in CBI technology have in general been remarkably accurate as to the shape of the future, but consistently overoptimistic as to the timing of its arrival. This is in no way surprising. The movement of CBI R&D and the extent to which the technology is applied in actual training situations are, particularly within the military environment, governed by the availability of resources and the willingness of decision makers to expend them. Both technology development and applications are driven by resource issues. The ability of even experienced managers to predict the vagaries of budgeting, funding authorizations, and the future "popularity" of a given technical area has historically been little better than chance. The projections provided by Micheli, Morris and Swope (1980) for the 1985-1995 time frame are thus far in line with trends but are already beginning to slip in time course. Estimates of technology availability by Sherron's (1976) training decision makers have slipped at least 5 years in the decade since they were made. In the discussions which follow, we have thus avoided time course predictions and attempted only to detect broad tendencies for movement in certain directions. Given those qualifications, the paragraphs below present, with and without attribution to other authors, our idiosyncratic view of the future of CBI technology.

Trends in Delivery Systems. There is a steady convergence of CAI, simulation and gaming technology, both in the methods

employed and in the recognition of common elements by workers in the various fields. The subtle boundaries between these areas have all but disappeared in practice. We noted earlier that most training methodologies in the "high-tech" domains are some form of "computer-assisted instruction," from large scale flight simulators to simple text presentations. It is difficult to distinguish definitionally between a microcomputer-based maintenance trainer which simulates electronically the functions of a piece of actual equipment (a training device) and an interactive tutorial which models the functions and responses of the same equipment (CAI). This convergence has been accelerated by the emergence of ICAI (Groveston, 1982; Heines, 1983; Sleeman & Brown, 1982; Smith & Collins, 1983). There is movement within traditional CAI toward models of complex systems that can be exercised in "what if" modes (Anderson, 1980); the resultant training systems are not materially different in form or function from simulators or what has been typically isolated and treated separately as "games." In particular, the use of ICAI for training decision makers in tactics (Crawford & Hollan, 1983; Thorndyke & Westcourt, 1984), cannot logically be separated technologically from "wargaming" trainers for the same purpose.

Intelligent CAI and expert systems have become an inextricable part of CAI technology. They are not going to go away; they respond to real training problems and their growth and direction should receive explicit attention. As there is more focus on individual differences in learning, the "cognitive styles" of trainees, this penetration of CAI by the ICAI approach will increase. There is progressive emphasis in both CAI/ICAI and in many kinds of simulation on modeling various components of the training process -- students, instructors, system hardware, opponents and expert strategies (Richardson, 1983). For some time to come, ICAI implementations will work well in "one shot" applications and stand-alone systems (Wolfe & Williams, 1979), but assimilation of expert systems and similar new mechanisms for instruction into the applied community will

be slow due to high cost, resistance to innovation, and difficulty with integration into existing delivery structures.

In addition to increased use of ICAI as an instructional medium, we also see steady increases in the use of more sophisticated instructional delivery hardware. There will be greater use of audio (voice) and video (disc and cassette) and more coordination between the two presentation modes. As costs drop, greater emphasis on graphics will occur, particularly in training for maintenance and complex systems operation and in gaming approaches. Miniaturization will allow powerful self-contained delivery systems to be packaged in portable devices that serve both training and job-aiding functions (Wisher & Boycan, 1984). As our survey participants (Section VI) indicated, however, drivers for development of training delivery hardware will not come from within the CBI field; developers will take what emerges from other technology development areas and adapt those capabilities to instructional applications.

Trends in Instructional Development. We believe that three related thrusts will dominate instructional development technology in the near future.

a) There will be continued development of intelligent authoring systems and languages. The gradual incorporation of expert knowledge about how to train and how to construct effective training systems will significantly increase the power of an SME to translate his subject matter knowledge into quality instructional materials. Movement will be toward the realization of an "intelligent partner" as an adjunct to the instructional development team (Bunderson, 1978; Schwartz, 1983). The time course of this development is highly uncertain; R&D in this area is extremely expensive and progress will depend directly on the development resources made available.

b) The authoring systems concept will expand to cover progressively larger portions of the instructional development

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cycle. Linkages to the formal ISD process (Vineberg & Joyner, 1980) will increase and become more deliberate. Computer-based authoring systems will begin to function as job aids for ISD (Berkowitz & O'Neil, 1979; Braby & Kincaid, 1981; Schultz & Wagner, 1981), replacing much current paper guidance on how to use the ISD process. Expansions will include emphasis on computer-supported job analysis and generation of task lists, and other operations currently performed manually. New capabilities will serve both in performing the tedious bookkeeping functions involved in ISD (Ace, Sendefer & Sciutti, 1983) and in generating and conducting tradeoffs among alternatives (Kearsley, 1984; Kearsley & Seidel, 1985). There will be tendencies toward inclusion of explicit instructional theory as an embedded part of the development package, with greater attention to "pedagogical" or "how to teach" issues (Merrill & Wood, 1984).

c) Instructional development support packages will become both larger and more sophisticated (as discussed above), and simpler and less computationally extensive, with an explicit and deliberate divergence for the two classes of methods. Simpler packages usable on microcomputers will emerge, capable of effective guidance for simpler applications. This trend is already apparent in the commercial arena (see Locatis & Carr, 1985). These trends will simultaneously increase both power and accessibility of development software.

Trends in Control of Instruction. As earlier sections discussed, much of the CBI applications gap is attributable to a generalized resistance on the part of the ultimate user community to innovation in the training and education process. While some of this lack of acceptance is due to a lack of understanding of the objectives of new methods, by far the largest part results from disagreement as to who (or what) should control the phasing, sequencing and scheduling of instruction. As Kearsley, Hunter & Seidel (1983) have noted,

there is a body of hard-earned knowledge about how to overcome this resistance to innovation. As this knowledge increases (and if it is properly applied), we see several distinct shifts in control of instruction and instructional development.

a) There will be a steady (but not rapid) movement toward understanding and acceptance of individualized and self-paced instruction. This will require an explicit education process for training managers and instructors in the role of individual differences in training and the benefit of capitalizing on those differences in terms of eventual operational readiness. As this acceptance evolves, there will be a gradual erosion of the more rigid and lockstep scheduling characteristic of the majority of current military training and an accommodation of methods for managing student thruput to the requirements of new technologies.

b) As ongoing "cognitive research" in the CAI context matures (Gagne & Dick, 1983), there will be a gradual assimilation of results into mainline training and education methods. Emphasis on individual differences in learning styles will eventually become systematized, and understanding of proper use of learner control and pacing knowledge will lead to "rules" for appropriate application of self vs. group paced methods. As Hall & Freda (1982) suggest, individualized instruction works better for some outomes (procedural knowledge) than for others (rule and principle learning). As such distinctions become clearer, more effective use of "cognitive style" will be possible. The increasing maturity of cognitive research will trigger a corresponding shift toward R&D on CAI as a method of instruction rather than as a delivery system. Wexley (1984) and Gerlach (1984) note the paucity of work related to the former construct, and emphasize the importance of CAI developing its own theories of instruction, rather than importing those which were developed from other non-CAI experiences and contexts.

c) Micheli, Morris and Swope (1980) forecast a shift toward centralized management of instructional development, with

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gradual decentralization of implementation and with local management and control of student flow. Economic necessity will to some extent force continuation of that trend and dictate the need for multi-use and shared courseware within and across services (Dallman, et al., 1983). Considerable ongoing work is toward the direction of that forecast. Some current programs discussed in Section VI provide for development of instructional packages and courseware on mainframes with explicit provision for downloading to microcomputers at the individual unit level for implementation.

Getting Payoff from the Technology

We have identified above an assortment of possible futures for CBI technology. While the time frames are nebulous, we believe that most of those projections will eventually come to pass in the normal evolution of events. It is also true, however, that acceleration of the time course for many of these trends is both possible and beneficial for military training. Allocation of increases or decreases in development resources serves to some extent as an intervention in the technology evolution processs. Decision makers should consider both benefit and risk issues; there are dramatic differences in both among the potential trends. From our review, we believe that certain sequencings of the possible developments are more likely to be beneficial, since some accelerations offer leverage that will enable others to occur as a matter of course. We present below some limited recommendations for emphasis.

a) Since a major obstacle to implementation of existing CBI capability is acceptance by working-level users, specific attention to that issue is likely to provide both long and short term benefit. In our judgment, the key to increased acceptance is information on the workings and benefits of new technology, readily accessible and presented in terms of implications for operational users. As later sections will show, the user-oriented data base to which this report is addressed is a

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straightforward mechanism for providing this information. Development of the data base should be accompanied by a focused "marketing" program aimed at making its availability known to potential users. Without such a mechanism for disseminating information, new capabilities resulting from many of the above developments may have many of the same implementation problems encountered with existing methods.

b) The expansion of authoring systems to support the broadest possible range of ISD phases and tasks, and the addition of "intelligence" to these systems through incorporation of expert strategies, provides a means of direct implementation of new developments as they become available. Such systems also extend the capability of the system developer, and insert into the ISD process some explicit mechanisms for quality control, by removing some of the "artistic" individual differences in selection of approach and development of instructional materials. Such "automated" ISD, like the data base on technology capabilities, allows the best opportunity for incremental introduction of new methodology to the instructional development community.

c) The development of simplified, low-cost authoring approaches should be considered for a higher priority than at present. We have suggested previously that many of the opportunities for CBI will occur in isolated units without access to large scale computation and are relatively straightforward in nature. Application of complex authoring systems to such requirements would represent technological overkill. Commercial developers of authoring languages have been far more responsive than the military R&D community to such simpler instructional situations. Adapting or making available to operational users some of these less powerful courseware development aids could significantly broaden the applications range for CBI. In this connection also the technology data base could serve as a means of providing availability information to potential users.

SECTION V
EXISTING DATA BASES

Overview

Previous sections have established that CBI users of varying backgrounds have requirements for different kinds of information. To a limited extent, previous discussions have indicated the general content of the technology data base necessary to respond to these requirements. Very little of the information needed presently exists in a form that can be collated, organized, and inserted into a storage and retrieval system. There are within DOD some existing data bases and data sources which are accessible for some of these requirements, i.e., descriptions of ongoing R&D in CBI and related areas, and research literature based on DOD-funded efforts.

Storage and retrieval systems described in this section are all that were identified by those persons interviewed or through our own resources. If not exhaustive, it certainly comprises the majority of DOD systems for access to CBI research data, and is representative of all the varieties of such systems.

While some of the data bases below are quite satisfactory to their users, others are considered inadequate or lie dormant from insufficient dedicated resources to update and maintain data currency. Others are not used regularly because of difficulty with data retrieval or because other methods of obtaining data (personal records, informal networks) are more convenient. For the limited number of systems identified, the following paragraphs discuss content, update methods, retrieval system and users.

MATRIS

The Manpower & Training Research Information System (MATRIS) works through the DTIC to provide specific information on

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certain DOD manpower and training (MPT) program elements. MATRIS was created to develop and maintain a decision support system for the Training and Personnel Systems Technology (TPST) community which would assist managers, planners, and policy makers at all DOD levels with research and development utilization. The users of the MATRIS data base are primarily DOD decision makers with respnsibilities in planning, programming, budgeting, evaluation, and analysis of R&D programs. MATRIS users can retrieve stored information which includes identifying data (i.e., funding, dates, researchers, and performing organizations) and narrative data (i.e., purpose, approach, and progress). The system is used to identify current research rather than to retrieve research reports.

MATRIS products include such data base summaries as a budget book for TPST R&D Program Descriptions, a Directory of Researchers, a Research and Studies Program Book, a Research and Technology Work Unit Summary Book, in addition to various ad hoc reports, and provisions for personalized satellite data bases. The users of these capabilities have highly specific needs for information on budget categories, work unit structures, goals and objectives, congressional categories, etc. The sources of MATRIS inputs include Manpower, Personnel and Training task and work unit summaries and program element project data.

Defense Technical Information Center (DTIC)

DTIC, the parent organization of MATRIS, stores and provides rapid retrieval of all DOD-funded R&D literature for DOD agencies and their contractors. Searches are available on an extensive series of keywords and are provided in a variety of formats including summary, abstract and complete documents. DTIC also has links, through the National Technical Information System (NTIS) to the National Institute of Education's Educational Research Information Center (ERIC) which accesses other federally funded R&D documents.

ARPANET

The ARPANET orginated in late 1969 as an experimental network and has evolved into a successful means of providing communication between computers. The ARPANET was divided in 1983 into two separate unclassified networks, ARPANET and MILNET. The ARPANET serves primarily as an experimental research and development network. The MILNET serves as an operational military network.

Members of the CBI research and development community contacted in the survey found the ARPANET well suited to their information needs. The electronic mail capability provides an informal network for communication with other researchers, bulletin boards for information notes, newsletters for information sharing, and many other services. While the information obtained through ARPANET is not summarized or placed in context, it is this type of information exchange and up-to-date R&D data that the R&D community can most effectively utilize. Information available in this manner is somewhat less valuable to other non-specialist users. The ARPANET allows the user to obtain only the data needed and provides many menus and choice points to search the system.

In-House Laboratories and Centers

Some of the potential data base users have created in-house information systems to track projects and to disseminate information within their environment. Review of these systems can provide a needed look at how the information is filed and retrieved and the type of utilization it receives. Since the creators of these in-house systems are a part of the potential market for the new CBI R&D data base, how and why they use their in-house system provides a good source for lessons learned for creation of a new system. These in-house information sources

could also provide supplemental inputs to satisfy other R&D data base requirements.

The Army's Program Manager for Training Devices (PM-TRADE) has a Mission Area Material Plan (MMP) which combines five data bases. The MMP is not in itself a data base for search and retrieval, but rather an automated report plan. The reports fulfill in-house requirements and the MMP is updated annually. This system produces a System Summary Sheet containing project title, deficiencies, descriptions, dollar values, and other needed information. A more specific listing, based on deficiency number, is available but it becomes classified when the number is inserted. The information is input by the principal investigators and each receives the completed collection of data in hard-copy form. The large document which results is cross-referenced and projects are identified by several methods to increase usability.

PM-TRADE has also created an in-house filing system for publications on file. Each functional area is responsible for inserting publications they receive which may prove useful to others. There are currently over 100 entries, with as many waiting for secretarial input. Each entry is put on a formatted sheet which requires pertinent publication data, plus keywords and an abstract. The keyword descriptors are at the discretion of the person making the entry, but consistency is maintained since the principal investigators work in specified areas. The system is still undergoing development and is not extensively utilized.

The training technology department of the Navy Personnel Research and Development Center (NPRDC) maintains a data base for in-house project reviews and project status. The principal investigators are responsible for keeping their projects up-to-date. The file was designed to provide final year-end reports, with search capabilities for periodic status reviews.

The program maintains all versions of the project summaries with a record of the person making the changes. The data base stores information for hierarchical retrieval, based on keywords and level of inquiry. Printing project summaries can be specified in a user unique format or in pre-formatted versions, ready for reports.

Both the Naval Training Systems Center (NTSC) (formerly Naval Training Equipment Center) and the Army Research Institute for Behavioral and Social Sciences (ARI) maintain computer supported R&D program data bases similar to those described above. These data bases contain narrative information about program purpose, scope, and plans along with milestones, schedule and progress information.

General Comments

As we have noted previously, there are many different kinds of users. All the data bases reviewed here provide either information on recently completed, planned or ongoing R&D work or access to the basic technical literature dealing with CBI. These are adequate to serve the needs of R&D managers and investigators to determine what work is in progress in the DOD labs or centers, but, in their raw form, are not readily usable by or accessible to most other classes of users. The undigested information in technical reports and articles as provided by DTIC or by in-house communication systems, while helpful to the R&D user, is of little or no value to the many other user communities with legitimate needs for CBI information and/or support. Major expansion of the concept of "data base" and the generation of considerable additional data is required to serve these latter users.

SECTION VI
FIELD COMMENTS

User Discussions

Comments from on-site visits with the data base user community ranged from feasibility issues to the specificity needed to make the data base useful. Table 3 summarizes the major comments from the interviews concerning data base issues. Discussions below paraphrase and expand user comments.

Overall, the community indicated that a data base, if designed with careful attention to the needs to the user, could provide a powerful source of R&D technology project status and state-of-the art summaries. Potential users (predominantly from the R&D community) currently rely on a network of information based primarily on personal contact and electronic mail links. There was solid agreement that the data base would, from the beginning, need to be as convenient and efficient as this network to replace it, and in addition would have to provide additional data not readily available from such a network. R&D users felt their current sources were adequate, up-to-date and convenient, and made it clear that the new data base would have to exhibit the same characteristics. One service a new data base could provide is to expand the user's current access to information, which at present is limited to specific areas of interest. Applications-oriented users would like ready access to state-of-the-art summaries of capability without having to do literature searches and reviews.

The user community would prefer a retrieval system that allows a hierarchical search mode. This system would require the user to progressively increase the specificity of the request to obtain the desired data. The level of data would then be dependent upon how much information is desired and the intended use once retrieved. This type of hierarchical system

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TABLE 3
USER COMMENTS-USER DISCUSSIONS

Feasibility/Need:

• The labs would like to have an active input into the data base file.

• Would like to have database use similar to a management information system.

• Success would be feasible if data base served to link levels of project progression, i.e. 6.1 → 6.2 → 6.3 →, etc.

• Could use a good "map" of what is out there to serve as a good source to broker information to facilitate technology utilization.

• Must be accessible and maintainable.

• Data base use must be mandated.

• Need to know where to go and how best to train on the new technology.

• Would like to see data bases in a common format so information obtained from each is transferable, similar in type and specificity.

• Would be helpful to have up-to-date catalog of what's happening in authoring languages (for instance).

Current Sources:

• Word of mouth network.

• ONR information base for theoretical research data.

• Electronic mail - ARPANET.

• In-house data bases, created to track inside programs.

• Library of Congress and other Federal Documentation sources.

• Own reading and files.

TABLE 3 (con't)
USER COMMENTS - USER DISCUSSIONS

Contents/Retrieval:

• Retrieval options must be flexible for unique search requirements.

• Would look for project descriptions; duplicate efforts, complimentary efforts; and the possibility of collaboration.

• Need hierarchical format.

• Information needs to include the people type issues and theoretical R&D.

• Principles of instruction should be included as well as modern learning theory and research psychology.

• Need to have modem access, compatible to a PC.

• Retrieval by keywords and subject matter.

• Should include a bibliography of reports from the project.

• Don't try to put everything into file, concentrate on retrieval flexibility.

• Where to go for information.

Configuration:

• Should be designed by a group, not just data automators.

• Should include all government programs.

• Should be a server through ARPANET.

• Take small "slice" first to demonstrate the value so that people will want to be in the data base.

Updates:

• Must be updated with interim information, do not wait until project is completed.

• POCs should be responsible for input, but data base maintainer should have someone to insure that it is current.

• Updates of every six months are not often enough.

• Is going to require someone to oversee maintenance.

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could provide a summary page with further information available, if desired. The user community would also like to have the content include a listing of relevant publications generated by a referenced project or closely related projects. This listing would provide literature sources which might be most readily available to the user. Retrieval content should deal with applications issues to assist those working on similar efforts. Application information would include the subject matter area on which the technology is being applied, the training approach, and the types of equipment utilized. Points of contact for obtaining additional data should also be given.

One user from the operational environment and one with training development responsibilities would like to see the data base contain analytical information such as decision models and confidence factors for the availability of proposed new methods. This configuration would make the CBI R&D data base unique in providing assessments and projections of the state-of-the-art for making decisions about applications programs. In the users' views, this would allow the earliest possible application of R&D products. Insertion of advanced training technologies is frequently difficult and discouraging to potential new application due to risks of feasibility and uncertainties about benefits and features. An analytical data base could help decision makers by summarizing technology features, pros and cons, configuration characteristics, areas of intended applications, probable costs, etc. The user could tap the data base when preparing a statement of work or conducting long range planning for a potential CBI training application. In addition, this summarized data on availability should be supported by one-on-one follow-up, if it is necessary to expand on search results. The data base contents and retrieval capability as envisioned by these users is almost identical functionally to the "consumers guide" and "file drawer" concepts introduced in previous sections.

Technology Discussions

In addition to obtaining comments on the potential needs of the user community, the field survey yielded opinions on CBI R&D trends and a sampling of R&D technology projects which would eventually provide products for incorporation in the data base (see Table 4). The majority of the personnel interviewed had a predictably optimistic view of where CBI will be directed in the coming years. The information provided is likely to be accurate, since many of the respondents are the R&D personnel who will be performing the future work. The objective of these discussions of technology trends was to obtain an idea of the technology information which the data base must accommodate in the near future.

There is a general belief among the R&D community that we will see more software development work and less hardware. This is in response to the need for more flexible systems which are transportable and compatible and for new technologies with more immediate application potential. It is felt that demands for new hardware technology in CBI are not as critical as the requirement for new means of manipulating, storing, retrieving and displaying information. R&D for unique CBI hardware is not a high priority. Several of the participants indicated that hardware should be derived from training requirements and that training should not be retrofitted to already developed hardware. Hardware developments should focus on efficient methods of input/output, high resolution of displays, improved communications, etc. to maintain high quality CBI. There appears to be some dissatisfaction with the efficiency of existing video output techniques, which have not kept pace with hard copy production technology. There are needs for improved computer support for CAI development, as well as in training delivery and management. There are noticeable shifts toward more directly applicable training R&D and away from high-technology developments that "look good" but lack demonstrated learning effects. The fast pace of CBI revolution

TABLE 4
USER COMMENTS-TECHNOLOGY DISCUSSIONS

Trends:

• The inclusion of behavioral science within the field of computer science.

• Toward software development, not hardware.

• Hardware technology aimed at increasing output efficiency.

• Requirement to put systems on a mainframe first, then on micros.

• More focus on the end product, not the user, i.e. the emphasis is on short-term payoffs for long-term solutions.

• AI research is stimulating theoretical research.

• Major words that drive current work: user-friendly, artificial intelligence, expert systems, authoring.

• Applications is the "in-thing" right now.

• Emphasis to develop portable systems at low cost.

Major Projects:

• Skills Training/Theoretical Research:
        Looking into skill commonality across jobs and tasks and the way people solve problems. Emphasis toward developing a new model for training complex skills. Principles of instruction must be married to technology.

• Advanced Maintenance Test and Evaluation Simulation System:
        Development of modular technology applications to maintenance, both hardware and software. Develop panel trainers so that government doesn't start from the beginning for each simulator contract.

• AI Testbed:
        Application of expert systems to perform instruction task and to model the instructor, in M-16 marksmanship training.

TABLE 4 (con't)
USER COMMENTS - TECHNOLOGY DISCUSSIONS

- Instructional Support System:
       System to provide extensive CMI support to instructors in major CBI programs (75% dedicated to CMI). Support for all administrative functions, such as recordkeeping, testing (creation, scheduling, evaluation), and data analysis. Program designed as a menu driven system with on-line help editor available which can be tailored by user.

- Training Technology Application Programs (TTAP):
       Overall Air Force program to integrate new technologies through-out the Air Force training community. Provides a process to develop, integrate and transfer technologies for training models, prototypes, networks and management. Numerous CBI specific projects under the TTAP auspices.

- Advanced Training System (ATS):
       Developed to accomplish six training delivery tasks: information presentation, demonstration, drill-and-practice, evaluation, feedback, and remediation.

- Personal Electronic Aid to Maintenance (PEAM):
       Portable information system for maintenance technicians. Joint-service program. PEAM is cartridge loaded, has large mass memory, is voice-interactive.

- Computerized Hand-held Instructional Prototype (CHIP):
       Portable, low-cost, multi-purpose CBI device with audio and video capabilities for use in nontraditional training environments.

has overlooked the realities of courseware development and instructional management, and these areas are now being addressed.

An additional requirement comes from the need for flexible systems on microcomputers, with trends toward initial development on a mainframe system, downloading to microcomputers for implementation. This allows a measure of flexibility during development to review options, select the best alternatives, and manipulate inputs and outputs for the best instructional result. There is an increasing (and unpopular) trend toward seeking short-term solutions for long-term problems. Short-term R&D is geared toward obtaining results that are responsive to specific systems or operational requirements. This precludes much useful creative effort in favor of more quickly applicable results, using variants of existing technologies. There is an almost universal feeling that this trend threatens the health of the future technology base.

The popular "buzz" words are consistent in recent years, i.e., user-friendly, artificial intelligence, expert systems, and authoring. Thrusts in the user-friendly area are designed to develop methods of partitioning tasks between instructor and machine to increase the efficiency of instruction. Artificial intelligence developments are regularly tracked for potential applicability to training. AI and expert systems can provide the learner with an extremely dynamic and effective learning environment. Authoring systems R&D can increase the use of CBI by making it readily available to those users who lack programming expertise. Emphasis is on increasing the efficiency of designers, authors, and planners through automation of training development support. Intelligent authoring systems, natural language interaction, programmerless authoring and automated media selection are examples of authoring development support projects currently underway.

Several groups are concerned with expansion of cognitive theories about human learning processes and their application to computer-based learning. One goal is to discover how people approach problem solving and how they interact with the computer. Learning theories and student pacing techniques have not kept up with training delivery technologies. A second goal is to determine the best ways to use new capabilities for modeling student knowledge to teach "concept formation" and to provide diagnosis and tutorial assistance.

Presented in Table 4 is a sampling of major projects from the CBI R&D community. These are by no means the only relevant projects, but are illustrative of the type of content that should eventually be represented in the data base. Each is discussed briefly below.

The "Instructional Support System (ISS)" at AFHRL (Lowry AFB) is nearing completion and is in preparation for on-site testing. The ISS was developed to provide a set of software modules for supporting CMI and CAI functions. This system will provide the instructors with powerful CMI support. The ISS is approximately 75% dedicated to CMI functions to assist the instructor in planning the course, scheduling, tracking, pacing, and testing the student. In addition, the ISS provides a flexible menu driven system to program overall course plans and to analyze resulting data. The ISS was developed on a mainframe system and is designed to be utilized on microcomputers when fielded. Software is written in Ada.

The "AI Testbed" currently being evaluated at the Naval Training System Center, in conjunction with the Army's PMTRADE, is a straightforward application of expert system technology. This program is applied to M-16 marksmanship training and is designed to model the instructor. This testbed will provide hard data on the applicability of expert system technology to training devices. Instructor models will supplement, rather

than replace, the instructor by providing additional feedback on training progress.

One of the projects at AFHRL (Brooks AFB) is "Skills Training and Theoretical Research." It examines the thought processes people utilize when solving complex problems. It will provide both new theoretical information and process models for the training of complex skills. When developed, models can be generically applied across the spectrum of training in problem-solving skills.

An NPRDC program, "Future Training Technologies," emphasizes the construction of CBI systems for teaching the operation of complex systems. It provides interactive simulations and automated tutorial/explanation capability. NPRDC has concentrated its efforts on decreasing the amount of programming expertise necessary to produce this class of system.

The Air Force has an ongoing program called the "Training Technology Applications Program (TTAP)" to facilitate development of technology models, prototypes, networks, management, integration, and transfer throughout the Air Force training community. The TTAP illustrates an organized method of technology control to develop instruction, train students, and manage resources. The top-down structured approach employed in TTAP is viewed as crucial for a systems approach to design and development of automated systems for ISD, and as an ideal tool for designing information network systems. The development is aimed at a structured analysis and system specification process that will logically flow into an efficient new physical description. The approach includes documentation, proof of concept and a requirements satisfaction review.

Another Air Force effort is the "Assessment of New Training Technologies" Project sponsored by the Air Force Air Training Command. This project provided insights into the CBT status

within the Air Force by assessing the state-of-the-art of training technologies and relating those capabilities to functional descriptions of current Air Force training. The overall goal of the project was to provide a set of recommendations designed to help ATC meet its short- and long-term skill training requirements. The two-phased project included: 1) the identification of the state-of-the-art training technologies and methods, and 2) forecasts of future training technologies. Findings are highly applicable to the project reported here and have been referenced frequently (Advanced Technology, 1985).

Among the ongoing CAI efforts in the Air Force is the "Advanced Training System (ATS)." The ATS is designed to accomplish six training delivery tasks: information presentation, demonstration, drill-and-practice, evaluation, feedback, and remediation. A management structure is also included. The ATS is expected to become operational in FY 85.

SECTION VII
CONSIDERATIONS FOR A CBI DATA BASE

User Issues

It was noted earlier that considerable discussion is devoted in the CBI literature to serving the needs of the technology user, with virtually no attention given to developing a clear picture of the user for whom that technology is intended. It became apparent early in our technology analysis that the potential users to which developers had oriented their products covered an extraordinarily wide range of background, experience, and formal training. The issue of concern was not so much that the range was inappropriate; there are clearly many levels at which use of CBI technology can occur. The difficulty was rather the apparent lack of awareness of the imprecision regarding the term "user", and the consequent lack of packaging of the technology to fit the skills and experience of the intended community.

The degree to which the user issue is satisfactorily resolved for a new CBI technology may well be the most crucial factor in determining the success of that technology; it may also be the critical driver in finding the best ways to organize and present a CBI technology data base. Typically, new CBI development systems emerging from R&D tend to be extremely complex and require considerable experience in subject matter and sophistication in courseware development. They are, as a result, costly to use for instructional systems development, and frequently require extensive support cadres to maintain continued quality instruction. For major military systems, such personnel and funding requirements may be acceptable, and the availability of front-end resources may allow realization of the improvements in instructional quality and overall reductions in life cycle cost possible with such systems. Such complex computer-supported development, however, may be inappropriate

for the many smaller and less ambitious applications that characterize much of military training and constitute (at least numerically) the greatest market for CBI technology. Johnson (1983) demonstrates that effective computer-based training can be achieved within the constraints of providing a technology package on a personal computer, usable by a chief petty officer with shipboard training responsibility but without formal training in courseware authoring.

The example given by Johnson (1983) is clearly at one extreme of the user spectrum. At the other is the type of large-scale training system defined previously which can both afford full CBI development and offer the cost-effectiveness leverage to benefit from it. In between these polar positions fall the vast majority of potential CBI applications, and it is for these training needs that considerations of cost, user sophistication and user willingness to "experiment" or take risks with new training approaches become paramount. Section IV provided a general user overview and summarized insights from the literature about some selected user classes. In the process of that review, we identified at least eleven possible types of user which technology developers might have had in mind when designing and documenting their instructional development systems. These are:

1) Subject matter experts (SMEs) with no formal training in instruction or courseware development,

2) SMEs with instructional experience but without computer based courseware training or experience,

3) SMEs with formal training in courseware authoring languages,

4) Instructional specialists without subject matter expertise,

5) Instructional specialists with subject matter background,

6) Training managers without instructional background,

7) Training managers with instructional experience but no CBI background,

8) Makers of decisions about how much and what kind of training will be provided,

9) The technology developers themselves,

10) The "superbeing" with all the above skills,

11) The trainee.

Each of these legitimate user classes benefits to some extent from CBI technology and from its improvement. It is, however, straightforward that such a range cannot be served by one or even a few different systems; complexity of a CBI system and the presentation of guidance on its use should be targeted more closely to user characteristics than has traditionally been the case. Likewise, the proposed data base which provides information about the characteristics and availability of various CBI technologies should reflect in its structure a similar sensitivity to the diversity of user background, experience, and interest.

The Classification Schema

Development of a classification schema was addressed as an effort to provide technological information to these diverse users. For this schema to be a useful structure for describing CBI system development technologies and their capabilities, it must, at a minimum, provide for collecting two primary kinds of information: 1) what the system is intended to do (Functions Performed), and 2) how it does those functions (System Characteristics). An abbreviated schema was prepared to use in field interviews to obtain feedback from data base users on its comprehensiveness and usefulness as a classification system. The taxonomic effort involved in a full-scale classification structure will be extremely complex. Our efforts are at best an indicative start; we thus refer to our "final" classification structure as a "strawman" schema.

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The _Functions_ of a system describe which of a number of possible activities are computer supported in the instructional process. Table 5 shows the first two levels of function performed (the abbreviated schema). The "final strawman" has a third and sometimes a fourth level of indenture (a total of 68 entries) and is contained in Appendix C.

The Function breakout is an expansion of a structure used by Peters (1982), modified by portions of the categorization used by Reigeluth, et al. (1982) and several others. Delivery of Instruction corresponds closely to the conventional uses of the term CAI. Management and Support describes the traditional content of CMI, although some authors now distinguish between the management of instruction and instructional administration as separate uses. The third category is less commonly included in definitions of CBI, but is a particularly crucial component of CBI technology. The presence or absence and the nature of computer support for such functions as courseware authoring are major features in distinguishing between alternative CBI development systems.

System Characteristics/Specifications can be thought of as a second dimension in describing CBI systems, with Functions and System Characteristics forming a two-way cross-reference matrix which could be used for structuring collection of system descriptors for the data base. Table 6 presents the first two levels of indenture for the Systems Characteristics outline (the abbreviated schema); the full structure of the strawman (a total of 85 entries) is contained in Appendix D. The top-level structure is similar to one used by Kearsley (1983), with subcategories based on inputs from a number of other sources.

The full strawman schema was reviewed by all but three of the individuals surveyed. Comments were generally favorable; no additions or changes resulted from the field interviews.

TABLE 5
FUNCTIONS PERFORMED

A. Delivery of Instruction

    1.   Tutorial-Mode CAI
        (computer as teaching medium)
    2.   Exploratory-Mode CAI
        (computer as teaching tool)

B. Management and Support of Instructional Delivery

    1.   Diagnosis and prescription
    2.   Student testing and feedback
    3.   Student progress management
    4.   Scheduling of instruction
    5.   Recordkeeping and reporting
    6.   Continuing evaluation/update/
        revision of training system
    7.   System networking

C. Support for Training System Development

    1.   Management of the development process
    2.   Authoring courseware
    3.   Developing instructional management software
    4.   Evaluating the delivery system

TABLE 6
SYSTEM CHARACTERISTICS/
SPECIFICATIONS

A. **Systems Hardware**

   1. Processor
   2. Architecture
   3. Student/Instructor input media
   4. Storage media for training materials
   5. Output media
   6. Portability
   7. Facility requirements
   8. Performance capabilities

B. **System Software**

   1. Operating system(s)
   2. Student/instructor interface
   3. Authoring language(s)
   4. Instructional management
   5. Programming languages
   6. Communications/networking
   7. Security provisions
   8. Licensing/restrictions on use

C. **Courseware**

   1. Instructional techniques used
   2. Transportability/commonality
   3. Source(s)
   4. Type/extent of documentation
   5. Type/extent of evaluation
   6. Extent/nature of instructor interaction
   7. Revision/updating provisions

D. **Costs**

   1. Hardware
   2. Software
   3. Courseware
   4. Personnel and staffing
   5. Operation/maintenance

In addition to the two major axes (Tables 5 and 6, Appendices C and D), there are other dimensions which would be of value in locating technology within a data base. One that might assist a user in selection of a CBI approach is the principal Areas of Application for the products of a system. This structure is not yet (and may never be) totally clear to the authors; major headings would be such global training applications as maintenance, schoolhouse, flight procedures, etc. This would provide the third axis of a "taxonomic cube" containing system descriptions. The structure of the CBI cube is represented in Figure 2. The fourth axis (or an alternate third axis) would involve a categorization of Training Outcomes, the desired end-product of the educational process.
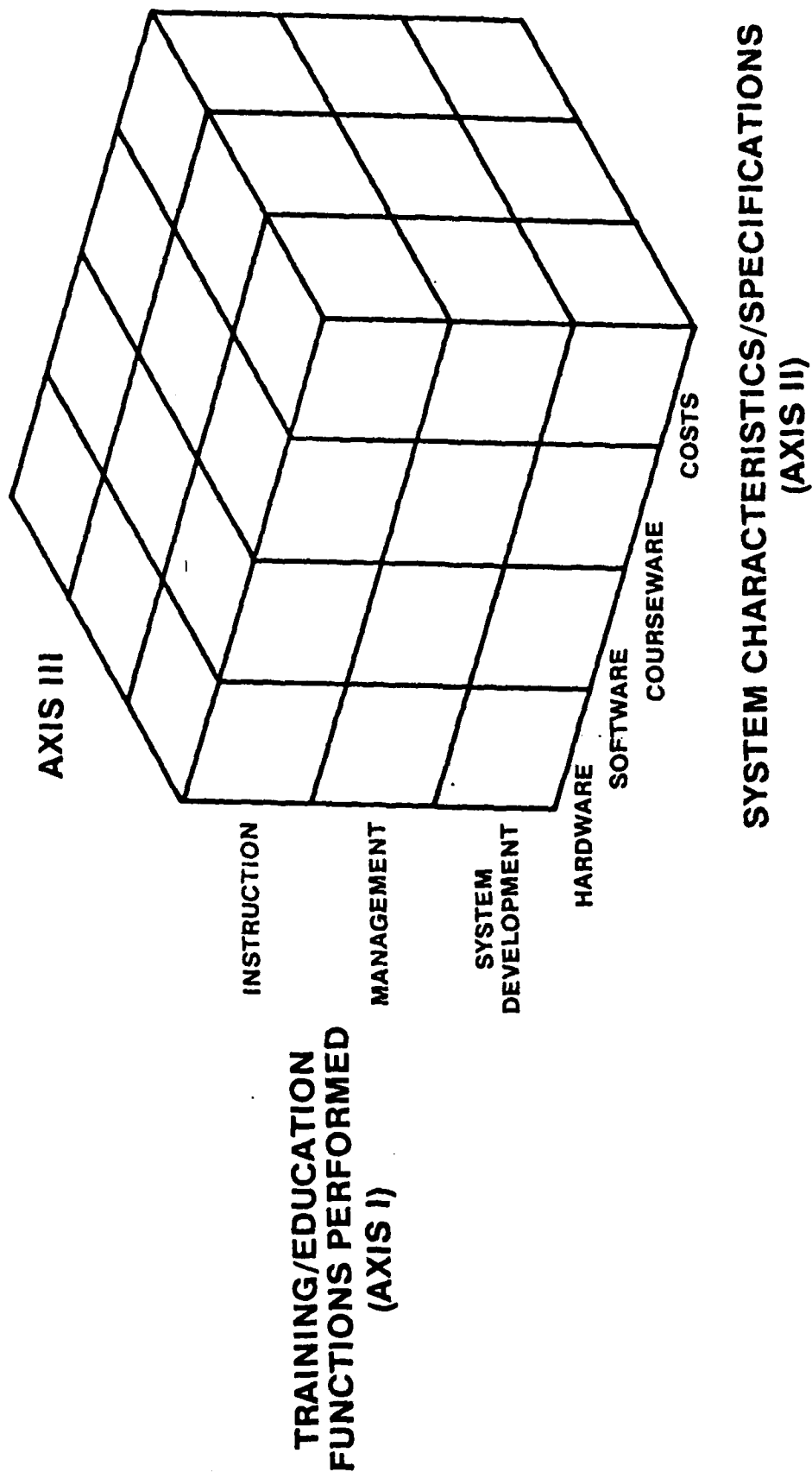
One such outcome breakout commonly in use is that of Gagne and Briggs (1979), with the familiar catalog of declarative knowledge, procedural knowledge, cognitive strategies, etc. Reigeluth, et al. (1982) present a series of categorizations from a number of authors, along with some supportive theory. Each categorization is compared with and mapped into the Gagne and Briggs (1979) list of outcomes. Developing an outcomes structure with sufficient richness and precision to describe the diversity of CBI systems is an imposing challenge. Most existing categorizations (including the Gagne-Briggs) are sparse in description of complex motor and perceptual learning, and the full spectrum of potential outcomes is not yet properly covered in any description of which the authors are aware. It is nonetheless a potentially valuable axis of the data base, and some version of an Outcomes outline should be considered as a data base storage and retrieval feature.

Classification Schema and the Data Base

To be of value, information in a data base must be collected, coded, stored, retrieved and presented in terms of some set of rules. These rules should be generative, that is,

CONCEPTUAL STRUCTURES FOR
COLLECTION OF SYSTEM DESCRIPTORS
FIGURE 2

AXIS III

INSTRUCTION

MANAGEMENT

SYSTEM
DEVELOPMENT

HARDWARE

SOFTWARE

COURSEWARE

COSTS

SYSTEM CHARACTERISTICS/SPECIFICATIONS
(AXIS II)

TRAINING/EDUCATION
FUNCTIONS PERFORMED
(AXIS I)

AXIS
I = FUNCTIONS PERFORMED BY CBI SYSTEM
II = CHARACTERISTICS OF SYSTEM
III-A = APPLICATIONS OF SYSTEM
III-B = TRAINING OUTCOMES

they should structure each phase of information manipulation and produce a consistent and orderly outcome. The classification schema presented above addresses primarily the data collection phase. It is, in its present formulation, conceptual in nature; each axis represents a broad range of questions of a similar type which should be asked about a CBI method or system. The four axes discussed are meant to prompt queries on the following categories of information about a potential data base item:

- What does it do? (Functions)

- How does it do it and what will it cost? (Characteristics)

- What does it teach? (Outcomes)

- What kinds of training does it support? (Area of Application)

The schema as presented is thus an instrument for structuring the data collection process, not a means of storing or retrieving information. Similar, perhaps comparable, schemata will be necessary to organize other phases of data base operation, in particular the keying of retrieval menus. Further extensive examination of CBI taxonomic issues will be required to develop and evaluate a structure appropriate for each phase of data base development and use.

SECTION VIII
CONCLUSIONS

The purpose of the proposed CBI data base is to provide a systematic and efficient way of determining the capabilities and availability of CBI technologies. Our analysis of the literature and the survey of participants establishes clearly that there is a need, and very likely an ultimate market, for such readily accessible "digested" information. The "consumers guide" version of the data base, similar to that suggested by several users, provides guidance as to a) what relevant technologies exist for a given training requirement, b) which of these are most appropriate for that requirement, and c) which could be executed within available resources. A data base oriented toward furnishing such guidance to a diversity of users is technically feasible, but logistically complex.

The data base and its contents will not generate itself spontaneously. It will require considerable up-front effort and a continuing investment of resources to maintain usefulness. The need for the data base to be created, managed, interpreted and actively supported implies coordination by a single organization charged with the responsibility to make it work.

A data base which contains only "undigested" information, i.e., project characteristics, work in progress and research citations, would be of limited value to the vast majority of potential CBI users. It would support only the CBI research and research management communities, groups which believe with some justification that their data needs are adequately met by existing mechanisms. While development of the full-scale data base is complex, it is debatable whether less ambitious attempts would be worthwhile.

SECTION IX
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APPENDIX A

COMPUTER-BASED INSTRUCTION:
GENERALIZATIONS FROM DOD EXPERIENCE

NORMAN E. LANE

Conference Presentation at

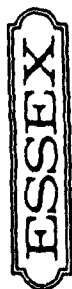RETRAIN AMERICA '85
Detroit, Michigan
18 June 1985

COMPUTER BASED INSTRUCTION: GENERALIZATIONS FROM DOD EXPERIENCE
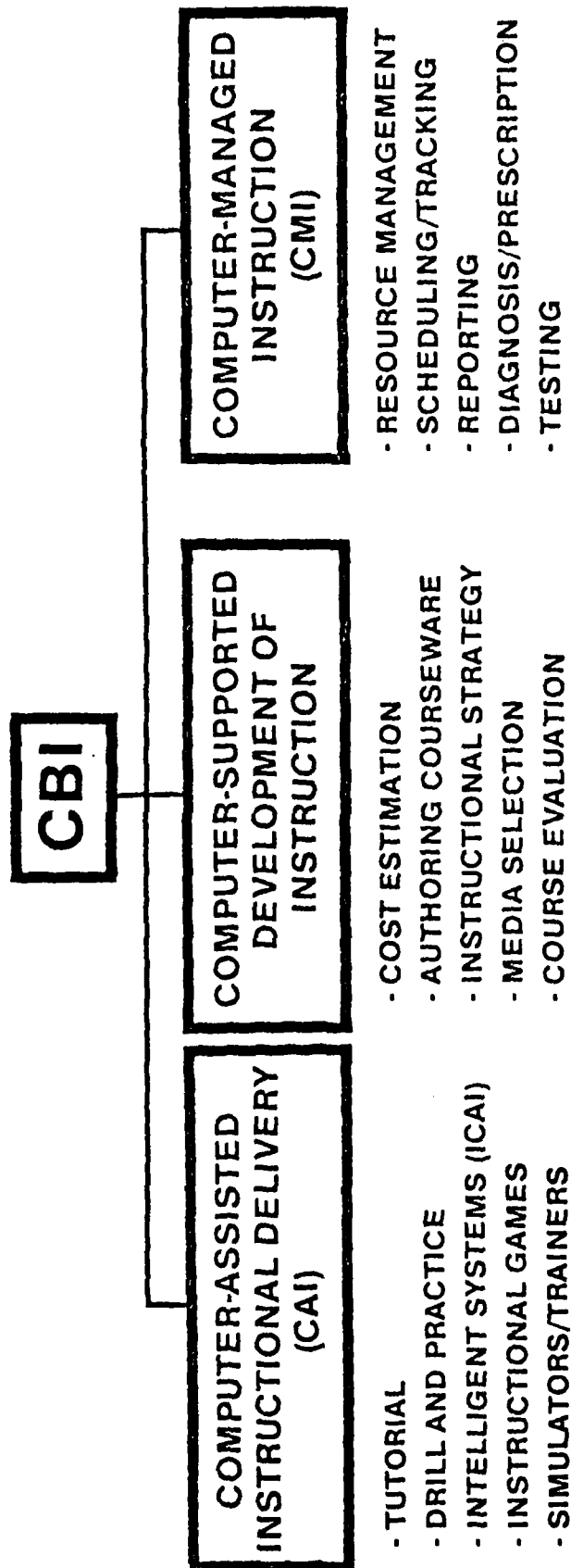
ESSEX

DR. NORMAN LANE
ESSEX CORPORATION
ORLANDO, FLORIDA

OUTLINE

ESSEX

- WHAT IS COMPUTER-BASED INSTRUCTION (CBI)?

- THE DOD EXPERIENCE WITH CBI

- MAKING EFFECTIVE USE OF CBI

- CONSIDERATIONS FOR INDUSTRIAL RETRAINING

WHAT IS CBI?

ESSEX

CBI

COMPUTER-ASSISTED INSTRUCTIONAL DELIVERY (CAI)

- TUTORIAL
- DRILL AND PRACTICE
- INTELLIGENT SYSTEMS (ICAI)
- INSTRUCTIONAL GAMES
- SIMULATORS/TRAINERS

COMPUTER-SUPPORTED DEVELOPMENT OF INSTRUCTION

- COST ESTIMATION
- AUTHORING COURSEWARE
- INSTRUCTIONAL STRATEGY
- MEDIA SELECTION
- COURSE EVALUATION

COMPUTER-MANAGED INSTRUCTION (CMI)

- RESOURCE MANAGEMENT
- SCHEDULING/TRACKING
- REPORTING
- DIAGNOSIS/PRESCRIPTION
- TESTING

A-3

GENERALIZATIONS

ESSEX

- **CONVERTING EXISTING INSTRUCTION TO CAI USUALLY NOT EFFECTIVE**
  - START WITH ANALYSIS
  - DECIDE OBJECTIVES BEFORE COURSEWARE DEVELOPMENT

- **GOOD INSTRUCTIONAL APPROACH MORE IMPORTANT THAN DELIVERY SYSTEM OR MEDIA**

- **CONTINUAL CHECKS WITH OPERATING UNITS ABOUT TRAINING ADEQUACY IS CRUCIAL**

MORE GENERALIZATIONS

● **USE CAI/CMI FOR WHAT COMPUTERS DO BEST**

   - AUGMENT, NOT REPLACE INSTRUCTOR

   - EMPHASIZE PRINCIPLES AND PROCEDURES

   - INDIVIDUALIZE/TAILOR INSTRUCTION

   - TEACH SYSTEMS DYNAMICS, INPUT-OUTPUT RULES

   - USE INTERACTIVE INSTRUCTIONAL APPROACHES

   - AVOID TEXT PRESENTATION (PRINTED MATERIAL BETTER)

   - USE AS FRONT-END, NOT SUBSTITUTE, FOR ACTUAL
     EQUIPMENT/OJT

EVEN MORE
GENERALIZATIONS

- CAI COSTS MORE, BUT CAN SAVE TRAINING TIME (30 - 60%) WHEN USED CORRECTLY

- CMI INCREASES TRAINING THRU PUT BUT NOT NECESSARILY QUALITY OF TRAINING

- ATTITUDES OF INSTRUCTORS AND STUDENTS GREATLY INFLUENCE CBI SUCCESS

- EFFICIENCY, EFFECTIVENESS AND IMPLEMENTATION COMPLEXITY ARE SEPARATE DIMENSIONS FOR EVALUATING CBI

MAKING BEST USE
OF CBI TECHNOLOGY
(WHAT THE DATA TELL US)

ESSEX

● **ATTITUDES**
  - TOP MANAGEMENT COMMITMENT
  - INSTRUCTOR PARTICIPATION AND SUPPORT
  - TRAINEE INTEREST

● **DEVELOPMENT OF INSTRUCTION**
  - GOOD INSTRUCTIONAL PRACTICE IS THE DRIVER
  - CBI IS NO PANACEA; USE IT WHERE IT WORKS
  - PLAN ON FRONT-END INVESTMENT

● **IMPLEMENTING THE SYSTEM**
  - FLEXIBLE USE AND SCHEDULING
  - TRAINED INSTRUCTORS
  - EXTENSIVE INSTRUCTOR/STUDENT INTERACTION
  - PERMANENT SUPPORT CADRE

CONSIDERATIONS FOR INDUSTRIAL RETRAINING

- COST ISSUES MAY DIFFER FROM DOD EXPERIENCE
  - AVOIDANCE OF FUTURE COSTS FROM DISPLACED WORKERS MAY OVERRIDE INITIAL INVESTMENT CONCERNS

- FOR SOME NEW JOBS, NO ALTERNATIVE TO CAI/ICAI APPROACHES
  - MONITORING/CONTROLLING AUTOMATED SYSTEMS
  - LIMITED AVAILABILITY OF ACTUAL EQUIPMENT
  - HIGH OUTPUT QUALITY REQUIREMENTS

APPENDIX B

INTERVIEWER'S GUIDE FOR USER SURVEY

USER DISCUSSIONS

On the issue of the feasibility of an R&D Data Base:

> Is information useful to community possible to be collected?
> Who would be major users?
> Update cycle recommended, to keep DB current?

Do you presently use an R&D Data Base?
> If yes, which one(s)?
> > how often?
> > for what types of information?
>
> If no, would you use one if designed differently?

Would you like to see another R&D DB, configured differently,
> which contains the information from the existing DBs?
>
> If no, why not?
>
> If yes, what are the critical areas for inclusion?
> > what are the critical issues in the retrieval
> > system?

How would you like to search such a DB?
> Oriented toward:
> > Student?
> > Instructor?
> > Hardware?
> > Software?
> > Program element?
> > Technology?
> > Subject matter?
> > Instructional technology?
> > Instructional strategy?
> > Other...?

What do you think will be the major sources of input?
> List:

How should data be collected?
> Based on taxonomy?
> Volunteer?
> From program element summaries?
> From other DBs and reformatted?
> Standardized questionnaire?
> Other?

B-1
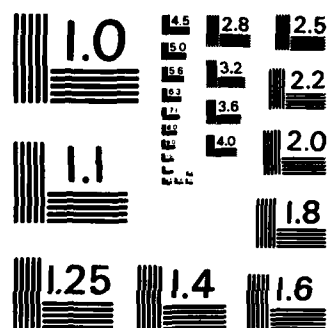
END

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MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

USER DISCUSSION (con't)

Level of specificity needed?
        General synopsis - Request information directly from
        POC?
        Form oriented, i.e. title, POC, PE, $$, summary?
        Just unique techniques & POCs?
        Other?

Once in the DB, how should the information be organized?

        Review Function and System Characteristics:
            Adequate for technology issues?
            Any critical gaps?
            Organization adequate?
            Need another major classification?
            Other?

TECHNOLOGY ISSUES

What do you see as the coming trends?

What are the areas of R&D intrests in terms of potential impact?

Are there any good <u>recent</u> technology surveys available?

Where would you like to see CBI R&D go?

What are you (or your group) working on in the technology area?
  (use interview survey list as discussion guide)

DISCUSSION FOR DATA BASE CREATORS

Name of Date Base –

Data Base Location –

Size/Number of Records – Files –

Updating Policy/Procedures/Time Frame –

Source of Inputs –

Storage Characteristics (file sample) –

Retrieval System/Key Words

How were initial inputs obtained?

How was input/storage/retrieval system designed? (decision process)

Who are intended users?

How does data base serve them in particular?

SECTIONS I, II, III:
(Considerations for discussions)

Data collection on R & D Project to sample an overall view of the types of current R & D projects and their characteristics.

Critical issues include: whether or not the project is unique to subject matter or generalizable to other applications; whether or not new technology is being developed or new applications/modifications to existing technology are being studied; whether or not another lab, service, etc. will be able to use the results; etc.

Could project information be stored in an R & D data base and if so, how would POC file the information?

...Does System have Characteristic (listed)?
...Is Charactertistic just part of system or a major focus under study?
...What is new or 'R&D' unique about Characteristic under study?

CBI DATA COLLECTION
R & D SYSTEM DATA
(For use with Sections I-III)

System Name:

Project Type:
    Study?
    Prototype Development?
    Operational Equip?
    Other?

System Status:
    Operational Date -
    Percent Complete -
    Other -

Service Command:

POC/Phone:

Equipment:
    Off-the-Shelf?
    Unique to R&D project?

    Type-

Input Device(s):
    Off-the Shelf?
    Unique to R&D project?

    Type-

Output Capabilities:

System Designed For:

Configuration: Timeshared _____ Stand-Alone _____
Distributed _____

System Maintenance:

Generalization Features:

Unique Development Issues:

SECTION I - ISD DEVELOPMENT TOOLS

SUPPORT TO THE ISD PROCESS

ISD PHASE	Not Part	Part of Study	Focus of Study
PHASE I			
Analyze –			
Analyze Job	( )	( )	( )
Select Tasks Functions	( )	( )	( )
Construct Job Perf. Measures	( )	( )	( )
Analyze Existing Courses	( )	( )	( )
Select Instruction Setting	( )	( )	( )
PHASE II			
Design –			
Develop Objectives	( )	( )	( )
Develop Tests	( )	( )	( )
Describe Entry Behavior	( )	( )	( )
Determine Sequence & Structure	( )	( )	( )
PHASE III			
Develop –			
Specify Learning Events/ Activities	( )	( )	( )
Specify Instruction Mgt. Plan & Delivery System	( )	( )	( )
Review/Select Existing Materials	( )	( )	( )
Develop Instruction	( )	( )	( )
Validate Instruction	( )	( )	( )
PHASE IV			
Implement –			
Implement Instructional Mgt. Plan	( )	( )	( )
Conduct Instruction	( )	( )	( )
PHASE V			
Control – (Evaluation) –			
Conduct Internal Evaluation	( )	( )	( )
Conduct External Evaluation	( )	( )	( )
Revise System	( )	( )	( )

SECTION II - COURSEWARE CHARACTERISTICS

SURVEY CHECK LIST
FOR CBT CHARACTERICS

ADMINISTRATIVE RECORDKEEPING (CMI Subsystem)

Student -
SSN
Name
Class
Other

Instructor -
SSN
Name (s)
Class
Other

Reports (High Order) -
Individual (SSN Scores, Tests Items, etc.)
Class (Students who passed (failed) with
score/subpart score
Other

Performance Summaries -
Grades
Exams Taken/Missed
Path Through Tests (remediations by content areas)
Time Spent on Tests
Other

Automated Remediation -
Instructor Notification
Student Branching (Automatic to a certain level)

TESTING

Automatic testing at certain content breaks?

Immediate evaluation against criteria?

Remediation -
Timeliness
Level
Automation

Construction -
Set or Pool to choose from
Variable based on student performance

Section II - con't

DATA ANALYSIS

Item Analysis -
            Distractor Selected
            Correct/Incorrect
            Time Spent
            # of Items & Content Area Remediated

Class Analysis
            Overall results
            Class standing relative to other classes
            Content analysis

OPERATING MODES

Student

Instructional Programmer

Instructor

Systems Programmer

Administrator

SECTION III - AUTHORING CHARACTERISTICS

AUTHORING ISSUES

User Interface -
    Menu Driven
    Program Language
    Other

Uniformity of User Interaction -
    Sign-on
    Saving files
    Keystrokes
    Other

On-line Documentation -
    Helps
    Prompts

Archive and Back-up Facilities

On-line branching
    Specification while inputting
    Tracking of branches
    Other

On-line Input Checking -
    Form and syntax of entries
    Other

Debugging Tools -
    Correctness of user-enter data bases
    Other

Videodisc Preparation -
    Frame #
    Recordkeeping
    Other

APPENDIX C

FUNCTIONS OF COMPUTER-BASED TRAINING
AND EDUCATION SYSTEMS

FUNCTIONS OF COMPUTER-BASED TRAINING
AND EDUCATION SYSTEMS

A. DELIVERY OF INSTRUCTION

    1. Tutorial-Mode CAI (computer as teaching medium)

        a. Information/knowledge presentation
        b. Drill and practice
        c. Tutorial dialogue (Socratic ICAI)

    2. Exploratory-Mode CAI (computer as teaching tool)

        a. Simulation of equipment and environment (trainers)
        b. System/process models ("what if" exercises)

            (1) Games (competitive)
            (2) Data base inquiry/interaction

B. MANAGEMENT AND SUPPORT OF INSTRUCTIONAL DELIVERY

    1. Diagnosis and prescription

        a. Entry level assessment and assignment
        b. Within-course remediation

    2. Student testing and feedback

        a. Test construction and development

            (1) Item bank maintenance
            (2) Branching logic
            (3) Individualization of tests

        b. Testing of progress

            (1) On-line
            (2) Off-line

        c. Feedback to students

            (1) Progress
            (2) Diagnostic information
            (3) Next assignment

    3. Student progress management

        a. Progress tracking
        b. Progress/completion forecasting

4. Scheduling of instruction

    a. Scheduling student entry and load
    b. Scheduling assignments
    c. Scheduling instructor-student interaction
    d. Scheduling instructional resources

5. Recordkeeping and reporting

    a. Reports for instructors

        (1) Class summaries
        (2) Individual student report/cumulative history

    b. Reports for administrators/managers
    c. End of training processing

6. Continuing evaluation/update/revision of training system

    a. Test items
    b. Instructional materials
    c. Instructional mix
    d. Interaction of material/student aptitude

7. System networking

    a. Within system
    b. To other systems

C. SUPPORT FOR TRAINING SYSTEM DEVELOPMENT

1. Management of the development process

    a. Estimation of cost
    b. Estimation of resources
    c. Generation of milestones/schedule

2. Authoring courseware

    a. Author training
    b. Generation of course materials
    c. Instructional logic and strategies (sequencing)
    d. Item and response formatting
    e. Media selection support
    f. Manipulation of tasks/objectives data bases

3. Developing instructional management software

    a. Scheduling
    b. Tracking
    c. Testing
    d. Recordkeeping/reporting

4. Evaluating the delivery system

    a. Test items
    b. Effectiveness of instructional materials
    c. Instructional mix
    d. Instructional level/instructional complexity
    e. Interactions with student aptitude

APPENDIX D

COMPUTER-BASED TRAINING
SYSTEM CHARACTERISTICS/SPECIFICATIONS

COMPUTER-BASED TRAINING
SYSTEM CHARACTERISTICS/SPECIFICATIONS

A. SYSTEM HARDWARE

1. Processor

   a. Large mainframe
   b. Minicomputer
   c. Microcomputer
   d. Combination

2. Architecture

   a. Dedicated
   b. Timeshared with other functions
   c. Distributed

3. Student/Instructor input media

   a. On-line
      (1) Keyboard
      (2) Touch panel
      (3) Light pen
      (4) Mouse/joystick
      (5) Voice

   b. Off-line
      (1) OCR/machine scoring format
      (2) Card

4. Storage media for training materials

   a. ROM/RAM
   b. Disk/diskette
   c. Videocassette
   d. Videodisc

5. Output media

   a. Display/monitor
   b. Hard copy
   c. Disk/diskette
   d. Tape
   e. Audio (including voice playback)
   f. Speech synthesis

6. Portability

   a. Size
   b. Power
   c. Ruggedization

7. Facility Requirements

    a. Physical space
    b. Power
    c. Cooling/environmental

8. Performance capabilities

    a. Display/monitor
        (1) Size
        (2) Resolution/pixel addressability
        (3) Color
        (4) Text/graphics

    b. Number of terminals supported/supportable
    c. Maximum response time
    d. Random-access storage
        (1) Available
        (2) Required by system

B. SYSTEM SOFTWARE

1. Operating system(s)
2. Student/Instructor interface
3. Authoring language(s)
4. Instructional management
5. Programming languages
6. Communications/networking
7. Security provisions
8. Licensing/restrictions on use

C. COURSEWARE

1. Instructional techniques used
2. Transportability/commonality
3. Source(s)
    a. User developed
    b. Standard commercial
    c. Custom developed commercial
    d. Public domain

4. Type/extent of documentation
5. Type/extent of evaluation
6. Extent/nature of instructor interaction
7. Revision/updating provisions

D. COSTS

1. Hardware
    a. Base system
    b. Expansion (per station)

2. Software
   a. Base
   b. Expansion (per station)

3. Courseware
   a. Development (per instruction hour)
   b. Updating/maintenance

4. Personnel and staffing

5. Operation/maintenance
   a. Clock time basis
   b. Instructional time basis

END

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